

ASSESSING CROSS-INDUSTRY EFFECTS OF B2B E-COMMERCE

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Abstract: The productivity gain that an industry experiences by engaging in B2B e-commerce gets transmitted to other industries through input-output linkages. This paper considers a multi-industry equilibrium model that explicitly incorporates input-output structure to examine the propagation of productivity gain across industries and to provide a framework to quantitatively evaluate the overall impact of B2B e-commerce. This model also helps identify the industries with potential for largest impact on other industries. We also demonstrate how this model can be used to make projections of output growth that would result from the introduction of B2B in selected industries.

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1. INTRODUCTION

The economic impact of the Internet has already been visible: in commodity market, in capital market as well as in labor market. There has been a drop in prices of many consumer items. Online trading of stocks and bonds has increased over the years.¹ A sizeable portion of the labor force is employed in Internet related activities. As we will see shortly, the revenue generated and the number of workers employed by the Internet based economic activities have been so large that they can well be described as constituting an independent economic system. One characteristic feature of these developments is the speed. This Internet based economy has grown very fast within a very short period of time. Enough time has not elapsed to observe long-run economic impact of the Internet. Nevertheless, speculations abound. Economists are divided between predicting long-run growth and low inflation in one end, and dismissing it as a temporary phenomenon in the other. Although recent dot com bust has produced more skeptics than ever, it is important to recognize that the potential size and overall economic impact of the Internet is larger than what we can imagine today. However, given that the Internet has taken the world, or at least the advanced economies, by storm, it is worthwhile to examine some of the speculations for their substance.

From the point of view of business and economics, trading over the Internet, also known as electronic commerce or *e-commerce*, is the fastest growing Internet based economic activity in the present time. The phenomenal growth of e-commerce in recent times has the most visible effects on the consumption economy. The consumer items are

¹ As various surveys indicate, online brokerage in the United States has slowed down since the recession while in Asia and Europe it has increased substantially. See various articles at www.nua.ie/surveys/

cheaper online than in conventional stores.² Internet cuts down on transaction costs and makes goods available to consumers at lower prices. Moreover, consumers are exposed to a wider range of choices. This proliferation of e-commerce has an indirect effect: competition from the Internet has forced traditional retailers to cut their prices. The speculation among the experts, however, is that the business-to-business (B2B) e-commerce will have the largest impact in the economy.³ B2B e-commerce can simply be defined as transactions between businesses conducted over the Internet. Since it involves trading of goods in the intermediate stages of the production process the value and volume of transactions will relatively be high. Moreover, the gains from engaging in B2B e-commerce in terms of increased productivity or reduced cost have indirect effects on other businesses through various linkages. This paper examines the cross-industry effects of B2B gains that spill over through inter-industry interactions in the context of a multi-industry equilibrium model. It also identifies the sectors that have the potential for spreading the beneficial effects across industries by reducing costs. In particular, we are interested in direct as well as indirect (which is sometimes referred to as ‘second-round effects’) impact of B2B e-commerce across industries. The model provides a framework for quantitatively assessing the impact of B2B e-commerce across industries. From both qualitative and quantitative analysis it appears that some industries hold brighter prospects than others do.

The rest of the paper is organized as follows. In section 2, we provide a discussion on the definition of the Internet economy, its size and growth. We also discuss various

² ‘Prices of goods bought online, such as books and CD s, are, on average, about 10% cheaper (after including taxes and delivery) than in conventional shops.’ *The Economist*, April 1, 2000.

³ Gartner Group forecasts that global B2B turnover could reach \$4 trillion in America in 2003, compared with less than \$400 billion of online sales to consumers.

aspects of B2B e-commerce. Section 3 discusses how B2B e-commerce benefits industries directly by reducing costs or increasing productivity, and indirectly through various inter-industry linkages. We then present a simple multi-industry equilibrium model to evaluate how inter-industry linkages help the gains from B2B in one industry get transmitted to the others.⁴ First we specify the model and then define a competitive equilibrium. By explicitly introducing the input-output structure into the model we theoretically examine the impact of using the Internet for B2B e-commerce on the output and prices of different industries. Then we calibrate the parameters of the model so that we can make quantitative statements about the economy-wide impact of introducing B2B e-commerce in different industries. Section 4 investigates for each individual industry the effects of introducing B2B e-commerce on output of various goods in the economy. Quantitative implications of introducing B2B in a few industries have been worked out and included in this section. Section 5 includes our concluding remarks.

2. THE INTERNET ECONOMY AND B2B E-COMMERCE

Electronic commerce is an important and integral part of the burgeoning Internet economy, which is loosely defined to encompass all resources related to, and all economic activities based on the Internet technology. The transactions carried out between different agents, i.e., between retailers and consumers, between wholesale traders and retailers, or between firms, over the Internet, constitute what we know as e-commerce. Depending on who are on the two sides of these transactions, e-commerce is

⁴ This model qualifies to be a general equilibrium model in a very limited sense. It represents a production economy that does not have consumers and other agents. Nevertheless, it captures what we intend to analyze in this paper.

given fancy names. For example, when it involves transactions between business and consumers it is called B2C. Similarly, when such transactions are between firms, i.e., between businesses, it is named B2B. Before explaining the notion of B2B e-commerce and its economic significance we will have an overview of the Internet economy, its size, structure and growth.

2.1 The Internet Economy

In a recent comprehensive study conducted by the Center for Research in Electronic Commerce of the University of Texas at Austin, the Internet economy has been defined as ‘a complete economic system consisting of (i) ubiquitous, low cost communication networks using Internet technologies and standards, (ii) applications and human capital that enable business to be conducted over this network infrastructure, (iii) interconnected electronic markets that operate over the network and applications infrastructure, (iv) producers and intermediaries providing a variety of digital products and services to facilitate market efficiency and liquidity, and (v) emerging policy and legal frameworks for conducting business over the Internet’ (page 7). In this new emerging economic system, information plays the key role, a role that is played by the physical assets in the traditional economy.

According to this study, in 2000 the Internet economy employed 2.476 million workers and generated half a trillion dollars in revenue. Various studies indicate increased use of internet in every walk of life.⁵ According to a report from the Online Publishers Association and ComScore, consumer spending on online content in the US

⁵ These studies are cited and reported at www.nua.ie/surveys/

totaled USD1.3 billion in 2002, that marks an increase of 95 percent compared to 2001. eMarketer predicts that by 2004, worldwide e-commerce revenues would total USD2.7 trillion. According to this research company's latest report, the US will account for over one-half of worldwide revenue. A study by Nielsen-Netratings reveals that the top traditional advertisers increased their share of online advertising by 30 percent by the end of 2002. More than 22 million US Internet users visited an online tax services website during February 2003. New research from Pew Internet and American Life indicates that two-thirds of politically engaged Internet users during the 2002 election cycle sent or received email related to the campaign. The fact that America's leading cable and DSL providers added a combined 6.4 million high-speed Internet subscribers during 2002 is evidence of continuing expansion of the Internet economy. Leichtman Research Group forecasts that the total number of broadband cable and DSL Internet subscribers in the US will surpass the number of narrowband subscribers in 2005 and will grow to nearly 49 million by the end of 2007. New jobs are being created to cater to the needs of this ever expanding Internet economy. Workers are being shifted from other vocations to take advantage of new opportunities. The convenience, flexibility and efficiency of doing business through the Internet have contributed to this phenomenal growth of this emerging Internet economy. There is no doubt that the Internet economy is going to be a major contributor to the U.S. economy.

2.2 What is B2B?

E-commerce is the fastest growing segment of the Internet economy. Within this segment, B2B e-commerce is considered to have the brightest prospect of future growth

and expansion. As we have already mentioned, it has been projected that the B2B will soon outpace B2C with its turnover growing up to ten times higher by the end of year 2003. The Goldman Sachs Report on the e-commerce has defined 'B2B' as 'business-to-business commerce conducted over the Internet' (page 2). B2B has two major components: 'e-frastructure' and 'e-market'. Auction solutions software, content management software, and web-based commerce enablers constitute what the report calls 'e-frastructure'. Essentially, these three components provide the infrastructure for conducting electronic commerce. On the other hand, the 'web sites where buyers and sellers come together to communicate, exchange ideas, advertise, bid in auctions, conduct transactions, and coordinate inventory and fulfillment' constitute the marketplace where the e-commerce actually takes place.

3. HOW DOES B2B AFFECT PRICE AND OUTPUT ACROSS INDUSTRIES?

In addition to the speculation that B2B itself would evolve into a revenue-and-employment generating business, it can as well be argued that it would have beneficial impact on traditional industries. Since B2B e-commerce is directly associated with the production process of the industries the impact could be widespread. By improving flow of information it would ensure allocation of resources to their most productive uses, and thus would make markets more efficient. Efficient allocation of resources would make production process less costly and therefore more productive.⁶ Since industries are linked to one another as buyers and sellers of inputs, the productivity gain to an industry that is

⁶ It is easier and more obvious to argue in terms of cost saving effect of B2B e-commerce rather than in terms of productivity gain. However, in order to help explain the specification of our model, we would stick to the productivity gain argument. But they are essentially the same.

engaged in B2B e-commerce, will eventually spill over to other industries through various linkages. Thus, B2B e-commerce will have economy-wide effects.^{7,8} However, how the gain in one particular industry affects other industries in the economy depends on which industry experiences these productivity gains, and on the nature of its interactions with other industries in the economy.

Intuitively, a productivity gain in an industry will entail a reduction in unit cost of its production. It implies that the price of its output will fall. If this particular good is used as inputs in other industries then it will lead to a reduction in the cost of production in the downstream industries, which in its turn will presumably lead to a fall in prices and rise in output of various commodities. On the other hand, since industries can now easily procure their intermediate inputs they would not accumulate large amount of inventory at a particular period of time. In other words, the scale of operation in terms of productive capacity will be smaller. Also, as the allocation of resources improves and as a result the resources become more productive, the demand for intermediate inputs or other resources might decrease. It may have negative effects on the upstream industries. Thus B2B e-commerce potentially has both positive and negative effects.

However, we would like to categorize the effects of B2B gain into direct and indirect effects. Direct effects are realized in the industries that purchase intermediate inputs through B2B e-commerce. If this productivity gain does not affect the demand for its output, these effects are expected to be in the form of rise in output and fall in prices.

⁷ We will refer to it as 'B2B gain'. In the business cycle literature it would have been referred to as a positive technology shock. In our exposition B2B gain is essentially a positive technology shock.

⁸ In fact, there is evidence of productivity gain from e-commerce in the U.S. economy in recent times. For example, as Oliner and Sichel (2000) have pointed out, if e-commerce enables goods and services to be produced and delivered using fewer resources, it could be one factor that has pushed up MFP (multi-factor productivity) growth in recent years'.

Indirect effects, on the other hand, are realized in other industries, which have downstream or upstream linkages with the industry experiencing B2B gain. In downstream industries it would look like a supply shock: price would fall and output would rise. In upstream industries it would look like a negative demand shock: both price and output fall. Total effects depend on the nature (whether positive or negative) and relative weights of direct and indirect effects.

In order to help us understand the direct effects, let us consider a partial equilibrium framework. Consider figure 1.a. In the short-run, industry i has an upward sloping supply curve S_i and faces a downward sloping demand curve D_i . Suppose the industry is in short-run equilibrium at E_i with equilibrium price P_i and output Q_i . As productivity increases as a result of B2B e-commerce the supply curve shifts to the right. This is represented in the diagram by S_i' . In the new equilibrium E_i' , price declines to P_i' and output increases to Q_i' . Note that in this illustration we have assumed that the B2B has not affected the demand for the output of industry i . B2B has similar indirect effects in the downstream industries. As we have discussed, indirect effects in the upstream industries, on the other hand, would look like negative demand shock. In figure 1.b, the demand curve faced by industry j , which provides intermediate inputs to the industry i experiencing B2B gain, shifts to the left for reasons explained above. The new equilibrium price and output are P_j' and Q_j' respectively.

However, in a more general framework, industries interact in such a complicated fashion that it is difficult to distinguish between downstream and upstream linkages among industries. Two industries may be linked to one another both as downstream and upstream industries. In such cases, it is difficult to infer what the net effect would be for

each of these industries. Moreover, the industry that experiences B2B gain could also be a major provider of intermediate inputs to itself. In such a situation, the positive impact of B2B gain could be neutralized by the negative impact of an opposite demand effect. In other words, since the industry now becomes more productive it uses less of its output as intermediate inputs. That is, the demand for its output falls. The net effect would depend on the relative magnitudes of the positive supply effect of productivity growth and the negative demand effect of fall in inventory accumulation. In brief, the productivity gain that is induced by the B2B e-commerce would set out a chain of changes that would work out through a complicated network of interactions among industries. Intuitively, it is not clear what the final effects would be. In order to capture the interactions among industries in the form of input-output relationship, we now construct a simple multi-industry equilibrium model that is capable of predicting the cross-industry effects of a B2B gain in individual industries. Note that this is a static model. However, there could well be dynamic effects of this type of productivity shock. After all, it is very likely that these productivity shocks will affect the economy with time lags. Also, there are other factors in the economy, which are important for the behavior of the economic variables. Since our aim is to evaluate short-run direct and indirect effects of B2B gain across industries, we are considering a simple production economy with an explicit input-output structure that captures inter-industry interactions. In the model, it is assumed that introduction of B2B e-commerce is an exogenous factor or a 'shock' that has positive productivity effect on the industries.

3.1 A Simple Multi-Industry Equilibrium Model

Model Specification

We assume that there are n industries in the economy. Each industry consists of large number of identical firms. The production technology available to a representative firm in industry i is given by the following production function⁹

$$Y_i = Z_i \prod_{j=1}^n X_{ij}^{a_{ij}} \quad (1)$$

where $a_{ij} > 0$ and $\sum_{j=1}^n a_{ij} < 1$ for $i = 1, 2, \dots, n$. Y_i is the output of industry i , Z_i is a random variable that denotes a shift in total factor productivity in industry i due to B2B e-commerce.^{10,11} Thus use of Internet will presumably increase productivity and that will be captured by Z_i s in our model. X_{ij} is the quantity of industry j output used as input in industry i . Since we have not explicitly introduced labor and capital in this production function one can interpret it as a short-run production function. That is, capital and labor do not change while intermediate inputs are the only variable factors. Thus the production function exhibits decreasing returns to scale in intermediate inputs. The firm maximizes its short-run profits subject to a constraint imposed by the technology given by (1). The short-run profit function for firm i is given by

$$\Pi_i = P_i Y_i - \sum_{j=1}^n P_j X_{ij} \quad (2)$$

⁹ The Cobb-Douglas production function is the most widely used production function in economics. Its wider acceptance is rooted in the fact that one of its inventors Paul Douglas inferred its properties from empirical observations of the US manufacturing during 1899-1922. Even now empirically, Cobb Douglas form well represents the production technology. In addition to the empirical appeal it has nice properties such as convexity, twice differentiability and homogeneity. For detail discussion, see Heathfield and Wibe (1987) and Johansen (1972). In recent times, most of the business cycle literature uses CD production function. For example, see King, Plosser and Rebelo (1988).

¹⁰ Actually this is the output of a typical firm in industry i . Since firms are identical we will use industry and firm interchangeably.

¹¹ It could be any technological change that affects productivity.

where P_i is the price of industry i output.

A market clearing condition for each industry completes the specification of the model. Thus

$$Y_i = F_i + \sum_{j=1}^n X_{ji} \quad (3)$$

where F_i is the amount used for final uses. This implies that available output of industry i is used either for final uses such as consumption, investment and government purchases or as inputs in other industries (including industry i). To highlight the importance of demand and supply of intermediate inputs in determining output and prices, however, we assume that F_i 's are fixed. The model is now solved for competitive equilibrium.

First-Order Conditions for Firm's Profit Maximization

$$a_{ij} P_i Z_i X_{ij}^{a_{ij}-1} \prod_{k \neq j} X_{ik}^{a_{ik}} = P_j \quad (4)$$

for all $i, j = 1, 2, \dots, n$

This condition states that the marginal revenue product of input j in industry i is equal to its price. Manipulation of the equilibrium condition (4) yields

$$X_{ij} = a_{ij} \frac{P_i}{P_j} Y_i \quad (5)$$

It is not difficult to see from this equation that as Y_i increases as a result of the exogenous productivity gain, *ceteris paribus* P_i decreases. On the other hand, as P_i decreases, demand for i^{th} input in industry k rises, i.e. X_{ki} increases, which in turn leads to an increase in Y_k as we can see from the production function. This will set out another chain of changes in prices and output. Thus it is the constant interactions between demand and supply that lead to cross-industry effects on prices and output.

A Competitive Equilibrium

A *competitive equilibrium* for this simple economy is defined as the quantity vectors \mathbf{X} and \mathbf{Y} and price vector \mathbf{P} such that for a given vector \mathbf{Z} of productivity shift,

- (i) the firms' profit maximization problems are solved.
- (ii) all markets clear.

Let \bar{X}_{ij}, \bar{Y}_i & \bar{P}_i be the competitive equilibrium solutions of X_{ij} , Y_i and P_i 's in terms of $Z_i = \bar{Z}_i$'s. Since we are interested in the effects of displacements in total factor productivity from \bar{Z}_i 's on the choices variables X_{ij} , Y_i and P_i 's, we state the following theorem.

Theorem 1: In a production economy, if industries are inter-linked through input-output structure, then the percentage deviations in X_{ij} , Y_i and P_i 's from these equilibrium values \bar{X}_{ij}, \bar{Y}_i & \bar{P}_i respectively, are given by linear functions of z_i 's where z_i 's are the percentage deviations of Z_i 's from \bar{Z}_i 's.

Proof: (see Appendix)

Calibration

In order to make some quantitative statements about the effects of B2B productivity gains across different industries we now calibrate the model for thirty-five industry groups of the U.S. economy.¹² We follow the industry classification scheme of Jorgenson, Gollop and Fraumeni (1987). These thirty-five industries roughly match the 2-digit Standard Industrial Classification (SIC) of U.S. industries. The parameters that we need to calibrate are a_{ij} 's and s_{ij} 's. Fortunately, the Input-Output (I-O) Tables provide

¹² A list of these thirty-five industries along with the uses of their output is provided in Table 1.

information on how the industries at various levels of aggregation interact among themselves, which can be used to obtain the values of these parameters. In 1996 annual I-O tables, 95 industries are covered at the two-digit level.¹³ We consolidate the 1996 I-O direct requirement table to thirty-five sectors that we are considering here. Note that

$a_{ij} = \frac{X_{ij}}{Y_i}$, where X_{ij} is the amount of industry j output used as input in industry i and Y_i is

the total output of industry i . On the other hand, we use 1996 I-O use table to calibrate the

parameter values s_{ij} 's. $s_{ij} = \frac{X_{ij}}{Y_j}$, where X_{ij} is the amount of industry j output used as

input in industry i and Y_j is the total output of industry j .

4. CROSS-INDUSTRY EFFECTS OF INDIVIDUAL B2B GAIN

In this section, we examine how a B2B productivity gain gets propagated to other industries. First we look into the effects on real output in different industries of a one percent increase in productivity in a particular industry. We then use the potential savings and Internet penetration ratios estimated by Goldman Sachs for different industries to estimate the potential output gain in the economy, as implied by our model.

4.1 What Does a 1 Percent Productivity Gain in an Industry Imply for Real Output across Industries?

Figure 2 illustrates how a one percent productivity gain in each of the thirty-five industries affects real output across industries. As we can see from this figure, for each industry the effects on other industries are both positive and negative. It is difficult to

¹³ I-O classification is slightly different from SIC classification.

discern a general pattern. As we have discussed, positive supply shock and negative demand shocks are simultaneously at work to determine cross-industry effects of B2B gain. However, the net effect depends on the relative strength of the demand and supply factors.

From the figure, we can make a few general observations. First, when predominantly intermediate inputs or investment goods producing industries¹⁵ experience B2B gain, the magnitudes of changes in real output across industries are relatively large. For example, B2B gain to intermediate goods producing industries such as ‘agriculture’, ‘crude petroleum and natural gas’, ‘chemicals’, ‘petroleum refining’, ‘primary metal’, ‘electrical machinery’, ‘transportation’ and ‘communications’ and investment goods producing industries such as ‘construction’ and ‘machinery’ have large impact across industries. Second, three service industries, namely, ‘wholesale and retail trade’, ‘finance, insurance and real estate’ and ‘services’ have the largest impact across industries. As we can see from Table 1, more than half of their output is used for consumption purposes. Third, direct effects are not always positive. For example, the ‘construction’ industry and ‘transportation’ experienced negative direct effects. This implies that in these industries, the demand factors are more powerful so much so that the negative effects outweigh the positive impact of the productivity gain.

This model can be used to quantitatively evaluate the impact of B2B gain. We shall illustrate this with an example. Note that the matrix \mathbf{II}_y in the appendix describes how B2B gain to an industry affects other industries through input-output linkages. Each column represents the percentage changes in output of different industries as a result of 1 percent productivity gain that a particular industry experiences as a result of B2B e-

commerce. For example, the first column represents the percentage changes in output of 35 industries when the ‘Agriculture’ industry experiences a 1 percent productivity gain due to B2B e-commerce. In order to calculate overall effects in terms of change in total output as a result of 1 percent increase in productivity in each of the 35 industries we follow the following steps:

- 1) First we calculate changes in output of individual industries by applying the percentage changes along the corresponding column of the \mathbf{II}_y to respective gross output. For example, when the agriculture industry experience 1 percent productivity growth, we apply the percentage changes along the first column to the gross output of 35 industries in 1996.
- 2) We then add up the changes in individual industries to obtain the overall effect of B2B gain in the agriculture industry. However, this total effect can be divided into ‘direct effect’ and ‘indirect effect’. Note that the diagonal elements of \mathbf{II}_y represent direct effects of B2B gain. Once we calculate total effects and direct effects, we can obtain indirect effects by subtracting the direct effects from the total effects.

We use 1996 GPO data obtained from the Bureau of Economic Analysis to illustrate how we use the model to calculate the effects. The results are reported in Table 2. As we can see, B2B e-commerce in ‘Services’, ‘Finance, insurance and real estate’ and ‘Wholesale and retail trade’ industry has the largest effects in terms of overall changes in output. These industries also have relatively large direct effects. B2B gain in the ‘Construction’ industry, on the other hand, has a large negative direct effect.

4.2 How Much Does the Economy Gain if the Cost Savings are as High as Estimated?

In the study '*E-Commerce/Internet*' conducted by Goldman Sachs, the percentage savings made possible by adopting B2B throughout specific industries have been estimated (see Table 2, Goldman Sachs(1999)). At the end of the report they also provide the Internet penetration ratios for different industries (Table 8). These are the estimated percentage shares of total sales that are or would be Internet based between 1998 and 2004. These two sets of industries they have studied do not match exactly. However there are a few overlapping industries. We take these overlapping or roughly matching industries from these two tables and match with the industrial categories we are considering in this paper. We select seven of our thirty-five industries, which roughly match their industries. Table 3 presents the estimated cost savings and Internet penetration ratios for the years 2000, 2002 and 2004 for these industries. We multiply the cost saving figures with the Internet penetration ratios to arrive at total cost saving for each of these industries. Then we calculate the total gain in terms of increase in real GPO for the economy as implied by our model. We take one industry at a time and see the direct, indirect and total effects of introducing B2B e-commerce. The results are presented in Table 4. We observe that B2B gain in the transportation industry would have the largest impact in the economy. Interestingly enough, it has negative impact on its own real output. However, the indirect effects are substantial. 'Transportation' is followed by 'chemicals' and 'crude petroleum and natural gas' respectively. The gain from B2B in the 'transportation' industry would grow by more than five times, those from the 'chemicals' industry and the 'crude petroleum' industry by more than four times and more than three times respectively. In case of all industries that we have considered here,

the indirect effects are several times higher than direct effects. It may be noted that the increase in the total gain from introducing B2B in the 'paper' industry would grow dramatically over the years. As for the overall impact, we see in last two rows that the total increase in output due to B2B in these seven industries accounts for only 0.21 percent of the US real GDP in 2000 whereas these seven industries together account for 10 percent. In 2004, this increase would account for 1 percent of real GDP whereas the projected share of these industries is only about 9 percent. However, one should keep in mind that these estimated numbers are not actual projection of the output gain in the economy. Nevertheless, given the data limitations this is the best we can do. Moreover, they give a very good idea of potential gain from B2B.

5. CONCLUDING REMARKS

In this paper, we examine cross-industry effects of the productivity gain that emanates from B2B e-commerce in various sectors. Within the simple framework of a multi-industry equilibrium model we introduce B2B e-commerce as an exogenously given productivity gain. Then we let the sectors interact among themselves to see how this exogenous productivity gain leads to change their input decisions, which eventually change price and output in each sector, by changing supply and demand. We observe that a B2B productivity rise in industries that mainly supply intermediate inputs or investment goods leads to fall in prices in a wider range of industries. In case of consumption goods industries, on the other hand, the effects are industry specific.

Given the simplistic nature of our model, the scope of our analysis is very narrow. However, in future research we would like to consider a more general setup and also to

introduce dynamics. This will allow us to examine broader issues like effects of the Internet on long-run growth and inflation.

APPENDIX: PROOF OF THEOREM 1

Firm i maximizes short-run profit given by

$$\Pi_i = P_i Y_i - \sum_{j=1}^n P_j X_{ij} \quad (\text{A.1})$$

subject to the constraint imposed by the technology

$$Y_i = Z_i \prod_{j=1}^n X_{ij}^{a_{ij}} \quad (\text{A.2})$$

The resource constraint for each sector i is given by

$$Y_i = F_i + \sum_{j=1}^n X_{ji} \quad (\text{A.3})$$

Substituting (A.2) into (A.1) and taking first-order derivative of Π_i with respect to X_{ij} , we obtain the following first-order condition

$$a_{ij} P_i Z_i X_{ij}^{a_{ij}-1} \prod_{k \neq j} X_{ik}^{a_{ik}} - P_j = 0 \quad (\text{A.4})$$

for all $i, j = 1, 2, \dots, n$

After algebraic manipulation and substitution of (A.2), we can rewrite (A.4) as

$$a_{ij} P_i Y_i = P_j X_{ij} \quad (\text{A.5})$$

Note that (A.2), (A.3) and (A.5) provide a system of $n^2 + 2n$ non-linear equations in $n^2 + 2n$ unknowns. This system can be solved for X , Y and P s as functions of Z s. Let

\bar{X}_{ij}, \bar{Y}_i & \bar{P}_i be the solutions of X , Y and P in terms of $Z_i = \bar{Z}_i$.

However, in this model we are interested in the effects of displacements in total factor productivity from \bar{Z}_i 's on the choices of variables X , Y and P s. Let us define

$$x_{ij} = \frac{X_{ij} - \bar{X}_{ij}}{\bar{X}_{ij}}, y_i = \frac{Y_i - \bar{Y}_i}{\bar{Y}_i}, p_i = \frac{P_i - \bar{P}_i}{\bar{P}_i} \text{ \& } z_i = \frac{Z_i - \bar{Z}_i}{\bar{Z}_i} \text{ where lower case letters denote}$$

percentage deviations from the equilibrium solutions.

Now in order to obtain linear solutions of these transformed variables in terms of z 's we first take logarithmic transformation of (A.5)

$$\log(a_{ij}) + \log(P_i) + \log(Y_i) = \log(P_j) + \log(X_{ij}) \quad (\text{A.6})$$

Using first-order Taylor series expansion around \bar{X}_{ij}, \bar{Y}_i & \bar{P}_i on both sides we obtain

$$\begin{aligned} \log(a_{ij}) + \log(\bar{P}_i) + \log(\bar{Y}_i) + \frac{1}{\bar{P}_i}(P_i - \bar{P}_i) + \frac{1}{\bar{Y}_i}(Y_i - \bar{Y}_i) \\ = \log(\bar{P}_j) + \log(\bar{X}_{ij}) + \frac{1}{\bar{P}_j}(P_j - \bar{P}_j) + \frac{1}{\bar{X}_{ij}}(X_{ij} - \bar{X}_{ij}) \end{aligned}$$

Using (A.6) and notations we have already introduced we can rewrite this as

$$p_i + y_i = p_j + x_{ij} \quad (\text{A.7})$$

Similarly, logarithmic transformation of the production function (A.2) first-order Taylor series expansion yield,

$$y_i = z_i + \sum_{j=1}^n a_{ij} x_{ij} \quad (\text{A.8})$$

Taking logarithm of the resource constraint, we obtain

$$\log(Y_i) = \log(F_i + \sum_{j=1}^n X_{ji}) \quad (\text{A.9})$$

Using first-order Taylor series expansion around \bar{Y}_i and \bar{X}_{ji} we now obtain

$$\frac{1}{\bar{Y}_i} (Y_i - \bar{Y}_i) = \frac{1}{F_i + \sum_{j=1}^n X_{ji}} \cdot \frac{\partial (F_i + \sum_{j=1}^n X_{ji})}{\partial X_{li}} \Bigg|_{X_{ji} = \bar{X}_{ji}} (X_{li} - \bar{X}_{li}) + \dots$$

$$\dots + \dots + \frac{1}{F_i + \sum_{j=1}^n X_{ji}} \cdot \frac{\partial (F_i + \sum_{j=1}^n X_{ji})}{\partial X_{ni}} \Bigg|_{X_{ji} = \bar{X}_{ji}} (X_{ni} - \bar{X}_{ni})$$

After algebraic manipulation, we can rewrite the above equation as

$$\frac{(Y_i - \bar{Y}_i)}{\bar{Y}_i} = \frac{\bar{X}_{li}}{\bar{Y}_i} \frac{(X_{li} - \bar{X}_{li})}{\bar{X}_{li}} + \dots + \frac{\bar{X}_{ni}}{\bar{Y}_i} \frac{(X_{ni} - \bar{X}_{ni})}{\bar{X}_{ni}}$$

or,

$$y_i = \sum_{j=1}^n s_{ji} x_{ji} \quad (\text{A.10})$$

where $s_{ji} = \frac{\bar{X}_{ji}}{\bar{Y}_i}$. Now substituting for y from (A.8) into (A.7) and (A.10), we obtain

$$p_i + z_i + \sum_{j=1}^n a_{ij} x_{ij} = p_j + x_{ij} \quad (\text{A.11})$$

and

$$z_i + \sum_{j=1}^n a_{ij} x_{ij} = \sum_{j=1}^n s_{ji} x_{ji} \quad (\text{A.12})$$

for all $i, j = 1, 2, \dots, n$

In matrix form we can write equations (A.11) and (A.12) as follows

$$\mathbf{M} \mathbf{v} = \mathbf{E} \mathbf{z} \quad (\text{A.13})$$

where \mathbf{M} is a $(n^2+n) \times (n^2+n)$ matrix containing parameters a 's, s 's, 1's and 0's; \mathbf{v} is a $(n^2+n) \times 1$ vector of x 's and p 's; \mathbf{E} is a $(n^2+n) \times n$ matrix of 1's and 0's and \mathbf{z} is an $n \times 1$ vector of exogenous productivity displacements. Rewriting (A.13),

$$\mathbf{v} = \mathbf{M}^{-1} \mathbf{E} \mathbf{z}$$

or,
$$\mathbf{v} = \mathbf{\Pi} \mathbf{z} \tag{A.14}$$

We can partition the vectors and matrix to derive the explicit solutions as follows:

$$\begin{pmatrix} x \\ - \\ p \end{pmatrix} = \begin{pmatrix} \mathbf{\Pi}_x \\ - \\ \mathbf{\Pi}_p \end{pmatrix} \mathbf{z} \tag{A.15}$$

where \mathbf{x} is an $(n^2 \times 1)$ vector of intermediate inputs (in percentage deviation form) and \mathbf{p} is an $(n \times 1)$ vector of prices. $\mathbf{\Pi}_x$ is an $(n^2 \times n)$ matrix that describes how B2B gain affects intermediate inputs and $\mathbf{\Pi}_p$ is an $(n \times n)$ matrix that describes how B2B gain affects prices.

Thus

$$p = \mathbf{\Pi}_p \mathbf{z} \tag{A.16}$$

and from (A.8) we obtain

$$y = (\mathbf{I} + \mathbf{A} \mathbf{\Pi}_x) \mathbf{z} = \mathbf{\Pi}_y \mathbf{z} \tag{A.17}$$

where $\mathbf{\Pi}_y = \mathbf{I} + \mathbf{A} \mathbf{\Pi}_x$ is an $(n \times n)$ matrix. Note that \mathbf{A} is an $(n \times n^2)$ matrix of a_{ij} s and

0s. *QED*

Figure 1.a
Effects of B2B Gain

'Direct effects' and 'indirect effects on downstream industries'

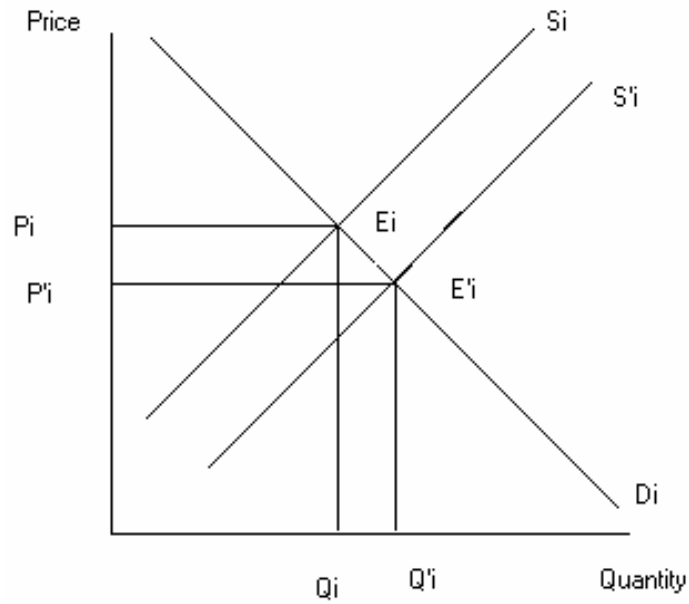


Figure 1.b
'Indirect effects on upstream industries'

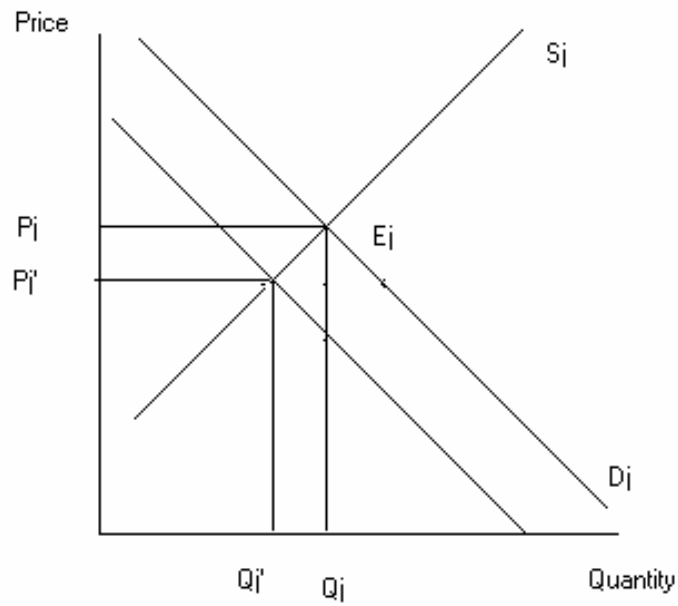


Figure 2
 Cross-industry effects of 1 percent increase in productivity due to B2B e-commerce

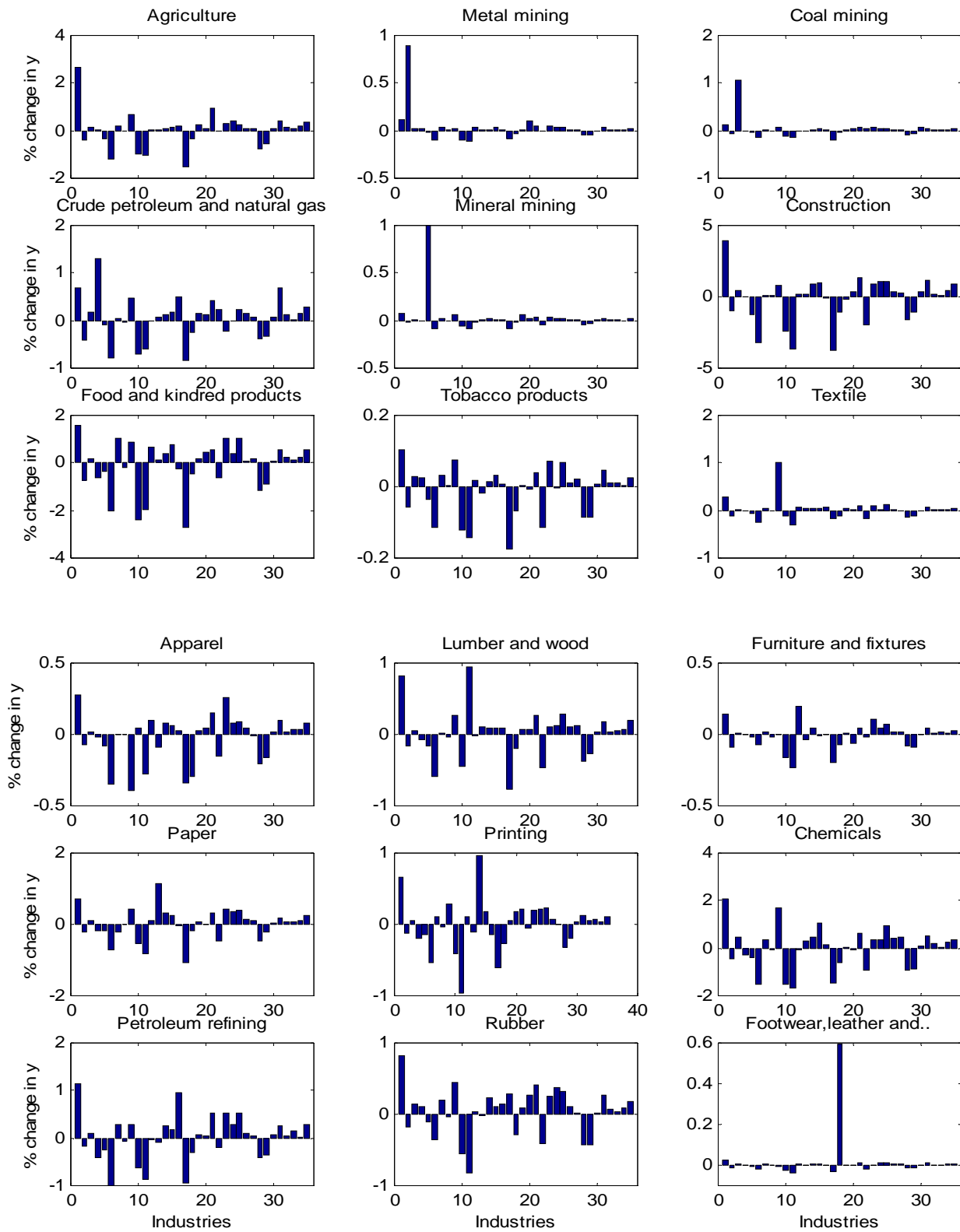


Figure 2 (continued)

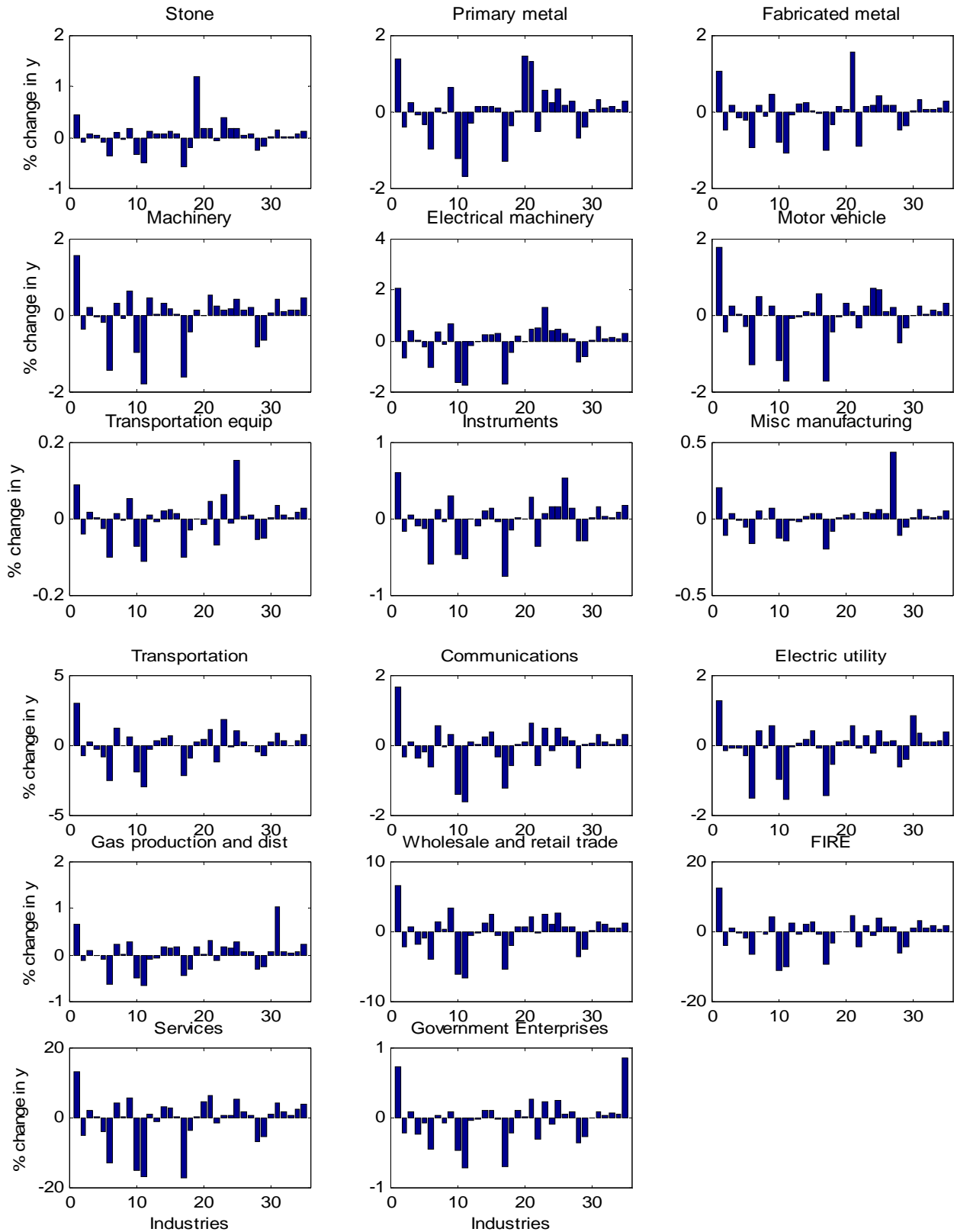


Table 1

Fractions of gross output in different uses by industry in 1996

Commodity/ Industry	Intermediate inputs	Consumption	Gross investment	Govt. purchases	Net exports (Exports -Imports)	Total
1 Agriculture	0.835	0.116	0.000	0.009	0.022	1.0
2 Metal mining	0.705	0.000	0.074	-0.023	0.251	1.0
3 Coal mining	0.885	0.002	0.000	0.004	0.098	1.0
4 Crude petroleum and natural gas	1.551	0.000	0.001	-0.004	-0.551	1.0
5 Mineral mining	0.979	0.003	0.000	0.005	-0.021	1.0
6 Construction	0.227	0.000	0.555	0.218	0.000	1.0
7 Food and kindred products	0.384	0.589	0.000	0.024	-0.001	1.0
8 Tobacco products	0.067	0.796	0.000	-0.001	0.131	1.0
9 Textile	0.849	0.134	0.044	0.007	-0.024	1.0
10 Apparel	0.334	1.107	0.000	0.030	-0.475	1.0
11 Lumber and wood products	0.946	0.026	0.080	0.002	-0.058	1.0
12 Furniture and fixtures	0.158	0.512	0.381	0.063	-0.119	1.0
13 Paper	0.876	0.113	0.000	0.033	-0.018	1.0
14 Printing	0.601	0.304	0.000	0.083	0.009	1.0
15 Chemicals	0.673	0.264	0.005	0.049	0.001	1.0
16 Petroleum refining and related	0.569	0.346	0.000	0.099	-0.024	1.0
17 Rubber	0.897	0.127	0.002	0.023	-0.056	1.0
18 Footwear, leather, and leather	0.481	2.152	0.000	0.031	-1.692	1.0
19 Stone	0.993	0.058	0.000	0.012	-0.070	1.0
20 Primary metal	1.096	0.001	0.001	0.005	-0.112	1.0
21 Fabricated metal	0.920	0.037	0.042	0.019	-0.027	1.0
22 Machinery	0.457	0.038	0.510	0.048	-0.054	1.0
23 Electrical machinery	0.722	0.165	0.175	0.054	-0.118	1.0
24 Motor vehicle	0.321	0.300	0.360	0.104	-0.093	1.0
25 Transportation equipment	0.109	0.421	0.244	0.247	-0.030	1.0
26 Instruments	0.304	0.095	0.408	0.197	-0.005	1.0
27 Miscellaneous manufacturing	0.312	0.949	0.151	0.058	-0.490	1.0
28 Transportation	0.583	0.238	0.020	0.051	0.107	1.0
29 Communications	0.475	0.433	0.021	0.055	0.015	1.0
30 Electric utility	0.489	0.413	0.000	0.102	-0.003	1.0
31 Gas production and distribution	0.628	0.320	0.000	0.048	0.004	1.0
32 Wholesale and retail trade	0.301	0.555	0.068	0.015	0.059	1.0
33 Finance, insurance and real estate	0.374	0.561	0.019	0.018	0.028	1.0
34 Services	0.391	0.570	0.037	-0.004	0.006	1.0
35 Govt enterprises	0.563	0.377	0.000	0.057	0.003	1.0

Source: Compiled from the 1996 Input-Output Use Table, Bureau of Economic Analysis

Table 2
 Direct and Indirect Effects of B2B Gain: An Example
 (Values in billions of 1996 dollar)

Industry experiencing B2B gain	Direct effect	Indirect effect	Total effect
1 Agriculture	3.48	5.57	9.05
2 Metal mining	0.05	0.62	0.68
3 Coal mining	0.14	0.98	1.12
4 Crude petroleum and natural gas	1.10	7.15	8.25
5 Mineral mining	0.10	0.35	0.45
6 Construction	-10.09	24.79	14.71
7 Food and kindred products	1.19	7.36	8.55
8 Tobacco products	0.00	0.19	0.19
9 Textile	0.25	0.69	0.94
10 Apparel	0.01	1.15	1.16
11 Lumber and wood products	0.37	2.66	3.03
12 Furniture and fixtures	0.04	0.50	0.54
13 Paper	0.65	3.93	4.58
14 Printing	0.90	2.17	3.07
15 Chemicals	1.63	6.60	8.22
16 Petroleum refining and related products	0.28	4.64	4.91
17 Rubber	0.14	4.95	5.08
18 Footwear, leather, and leather products	0.03	0.14	0.17
19 Stone	0.37	3.01	3.38
20 Primary metal	0.75	5.65	6.41
21 Fabricated metal	1.45	3.34	4.79
22 Machinery	0.35	6.78	7.13
23 Electrical machinery	1.85	8.27	10.11
24 Motor vehicle	0.59	4.00	4.58
25 Transportation equipment	0.08	0.40	0.48
26 Instruments	0.29	2.04	2.34
27 Miscellaneous manufacturing	0.11	0.95	1.06
28 Transportation	-1.09	19.30	18.21
29 Communications	0.06	8.39	8.45
30 Electric utility	1.76	5.78	7.54
31 Gas production and distribution	5.34	2.83	8.16
32 Wholesale and retail trade	7.30	24.61	31.92
33 Finance, insurance and real estate (FIRE)	25.01	29.10	54.11
34 Services	40.14	42.06	82.20
35 Govt enterprises	8.50	0.44	8.94

Note: The assumption is that there is 100 percent penetration of B2B.
 Source: Authors' calculations

Table 3

Estimated savings and penetration of B2B in selected industries for 2000, 2002 and 2004

Industry* with B2B	Estimated savings@	Estimated penetration of B2B (% share of projected sale based on Internet)		
		2000	2002	2004
Coal mining	2.0%	4.5	10.0	16.0
Crude petroleum and natural gas	10.0%	4.5	10.0	16.0
Food and kindred products	4.50%	1.1	1.3	1.6
Paper	10.0%	1.2	6.7	12.2
Chemicals	10.0%	5.0	10.5	20.0
Transportation	15.0%	2.5	6.5	11.0
Communications	10.0%	1.5	5.5	11.0

Notes: * The specific industries studied by Goldman Sachs have roughly been matched with our classification of industries

@ Wherever estimated savings are given by a range we have taken the average.

Source: Compiled from Table 2 and Table 8 of Goldman Sachs(1999)

Table 4

Estimated direct and indirect effects of B2B in selected industries for the years 2000,2002 and 2004:
 Changes in real gross value added
 (millions of 1996 constant dollars)

Industry	2000			2002			2004		
	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect
Coal mining	16	112.8	128.8	39.2	285.6	324.8	68.8	532.1	600.9
Crude petroleum and natural gas	328.8	3839.4	4168.2	577.3	8988.9	9566.2	721.8	14862.7	15584.5
Food and kindred products	41.5	420.6	462.1	42.3	579.4	621.7	44.5	860.5	905
Paper	95.8	559.7	655.5	574.8	3467	4041.8	1112.8	7258.7	8371.5
Chemicals	935.5	3635.7	4571.2	2039	7989.9	10028.9	3987.3	16232	20219.3
Transportation	-467.1	8914.2	8447.1	-1256.6	26153	24896.4	-2176.7	51451.5	49274.8
Communications	7.7	1106.1	1113.8	28.9	4389.9	4418.8	58.8	9694.3	9753.1
Total	958.2	18588.5	19546.7	2044.9	51853.7	53898.6	3817.3	100891.8	104709.1
Total effect as % of real GDP	0.01	0.20	0.21	0.02	0.53	0.55	0.04	0.96	1.00
Share of these 7 industries in real GDP			10.00			9.42			8.81

Notes: Gross value-added at 1992 constant dollars by industries are available from BEA until 1997. In order to be consistent with the 1996 I-O tables we converted them into 1996 constant dollars. Then we forecast GPO for the years 1998-2004 using growth rates for 1996. Note that we could have used the average growth rates for the decade of the 1990s. Since the beginning of the 1990s is characterized by recession that would not yield good forecasts.

Source : Authors' calculations

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