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JOBS, JOBS, JOBS:

COMMUNICATIONS POLICY AND EMPLOYMENT EFFECTS IN THE INFORMATION SECTOR

Abstract: The Federal Communications Commission has recently proposed a wide assortment of regulations for both wireline and wireless providers that may affect the investment decisions of firms. A number of recent studies conclude that employment, both in and outside the communications industry, is highly responsive to capital expenditures by communications firms. Consequently, it is argued that, depending on the response of firms to regulatory interventions, public policy may have significant positive—or negative—employment effects. In this BULLETIN, we present a new approach to measuring employment effects by estimating an "employment multiplier" using advanced time-series econometrics. Statistical testing indicates a causal relationship between capital expenditures and jobs in the Information sector. A 10% negative shock to expenditures in the Information sector results in an average loss of about 130,000 information-sector jobs per year in the ensuing five years. Including indirect jobs, these job losses could be as high as 327,600 jobs. Our econometrically-estimated employment effects are 40% greater than many earlier studies on this topic. The estimated employment multiplier is 10 Information sector jobs for each million in expenditure, and perhaps 24 jobs per-million across the entire economy. Lost earnings over a five-year period are estimated to be $100 billion. Moreover, we demonstrate that communications jobs are not typical jobs—these jobs (i) have median earnings 45% higher than the typical private-sector job; (ii) have proven relatively resilient to recessionary forces; and (iii) have a union membership rate over twice the national average, a statistic some policymakers will consider significant when evaluating regulatory policies that threaten investment incentives.

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I. Introduction

Due to a moribund economy and a persistent unemployment rate of about 10%, almost all public policy discussion in the U.S. today focuses on stimulating job growth.[1] Central to that goal is the need to create an environment that fosters investment and risk capital. Yet, as prior research has amply demonstrated, the Federal Communications Commission—particularly over the last two years—has proposed a wide assortment of regulations for both wireline and wireless firms that may adversely affect the prospect for additional investment and job creation.[2]

In this BULLETIN, we estimate the effect of changes in capital expenditures on employment by developing an "employment multiplier" using advanced time-series econometrics. This multiplier can be used to size the potential employment effects arising from regulatory-induced changes to capital expenditures. In large part, our econometric model indicates that the size of the employment effects found in several recent studies are plausible, even when one ignores the impact on jobs outside of the Information sector that is directly impacted by sector capital

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[1] Analysis of the recession is available at: http://www.nber.org/cycles/main.html. Unemployment data is available at: http://www.bls.gov/cps/lfcharacteristics.htm#unemp.

[2] *See, e.g.,* G. S. Ford and L. J. Spiwak, *The Broadband Credibility Gap*, PHOENIX CENTER POLICY PAPER NO. 40 (June 2010)(available at http://www.phoenix-center.org/pcpp/PCPP40Final.pdf) *and to be reprinted in* 19 COMMLAW CONSPECTUS (forthcoming Fall 2010); G. S. Ford and L. J. Spiwak, PHOENIX CENTER PERSPECTIVE NO. 10-03: *Non-Discrimination or Just Non-Sense: A Law and Economics Review of the FCC's New Net Neutrality Principle* (March 24, 2010) (available at: http://www.phoenix-center.org/perspectives/Perspective10-03Final.pdf); G. S. Ford and M.L. Stern, PHOENIX CENTER PERSPECTIVE NO. 10-02: *Sabotaging Content Competition: Do Proposed Net Neutrality Regulations Promote Exclusion?* (March 4, 2010)(available at: http://www.phoenix-center.org/perspectives/Perspective10-02Final.pdf); T. R. Beard, G.S. Ford and L.J. Spiwak, *Market Definition and the Economic Effects of Special Access Price Regulation*, PHOENIX CENTER POLICY PAPER NO. 37 (October 2009) (available at: http://www.phoenix-center.org/pcpp/PCPP37Final.pdf); G.S. Ford, L.J. Spiwak and M.L. Stern, *Expanding the Digital Divide: Network Management Regulations and the Size of Providers*, PHOENIX CENTER POLICY BULLETIN NO. 23 (October 2009) (available at: http://www.phoenix-center.org/PolicyBulletin/PCPB23Final.pdf); G. S. Ford, T. M. Koutsky and L. J. Spiwak, *Using Auction Results to Forecast the Impact of Wireless Carterfone Regulation on Wireless Networks*, PHOENIX CENTER POLICY BULLETIN NO. 20 (May 2008) (available at: http://www.phoenix-center.org/PolicyBulletin/PCPB20Final2ndEdition.pdf); R. Crandall and H. Singer, *The Economic Impact of Broadband Investment*, Study Sponsored by Broadband for America (2010) (available at: http://www.broadbandforamerica.com/press-releases/broadband-america-study-shows-importance-investment-0); C. Davidson and B. Swanson, *Net Neutrality, Investment & Jobs: Assessing the Potential Impacts of the FCC's Proposed Net Neutrality Rules on the Broadband Ecosystem*, Advanced Communications Law & Policy Institute, New York Law School (2010) (available at: http://www.nyls.edu/user_files/1/3/4/30/83/Davidson%20&%20Swanson%20-%20NN%20Economic%20Impact%20Paper%20-%20FINAL.pdf); C. Bazelon, *The Employment and Economic Impacts of Network Neutrality Regulation: An Empirical Analysis*, Consulting Report by The Brattle Group (2010) (available at: http://mobfut.3cdn.net/8f96484e2f356e7751_f4m6bxvvg.pdf); R. Crandall, C. Jackson, and H. Singer, *The Effects of Ubiquitous Broadband Adoption on Investment, Jobs and the U.S. Economy*, Consulting Report by Criterion Economics, L.L.C. (2003)(available at: http://www.newmillenniumresearch.org/archive/bbstudyreport_091703.pdf).

investments. Simulations based on our econometric model indicate that a 10% negative shock to capital expenditures in the Information sector (perhaps arising from new regulatory interventions) results in an average loss of about 130,000 information-sector jobs per year in the ensuing five years. Including indirect jobs, these job losses could be as high as 327,600 jobs. Lost earnings over a five-year period could be $36 billion in the Information sector alone and $100 billion for all affected jobs across the economy. Our calculated employment reductions are consistent with, for example, the estimates from Crandall and Singer (2010) and Davidson and Swanson (2010), both of which assume about 16.5 jobs lost per million in capital expenditure cuts. Per million of investment, we find 10 jobs are affected in the Information sector and perhaps 24 jobs across the entire economy. Accepting Davidson and Swanson's (2010) assumption of a $9.12 billion reduction in investment, we estimate an economy-wide job loss could be 220,000 jobs per year.[3] This job loss is 40% larger than that found in Davidson and Swanson (2010).

We also demonstrate that communications jobs are not typical jobs. The average earnings of a communications sector employee are about 45% higher than the typical U.S. private-sector job. Thus, each job lost or gained in communications is equivalent to about 1.5 average jobs lost or gained (in income terms). The telecommunications sector has proven relatively resilient to recessionary forces as well, with unemployment rates well below the national average. Further, about 17.7% of communications sector jobs are union jobs, versus 7.2% in private industry. For some policymakers, this higher union employment may be a significant consideration. In addition, capital expenditures in the communications sector are not typical capital expenditures. A reduction in investment in one sector may simply shift much of that investment to another sector, presumably having employment impacts there as well. As a matter of policy, the communications sector is unique in many respects, such as its role as a general-purpose technology and its potential for significant spillovers. Thus, capital in the Information sector may have a higher social payoff than capital in other sectors; a jobs analysis fails to consider this, understating the social payoffs of good communications policy (and the costs of bad policy).

II. A New Way to Look at the Problem

To date, numerous studies, including Communications Workers of America ("CWA") (2009),[4] Crandall and Singer (2003; 2010),[5] and most recently Davidson and Swanson (2010),[6]

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[3] Assuming $9.12 billion in expenditure change and a multiplier of 24.

[4] Communications Workers of America, *Proposals to Stimulate Broadband Investment* (2009) (available at: http://files.cwa-union.org/speedmatters/CWA_Proposals_Broadband_Investment_20081209.pdf).

[5] Crandall, Jackson, and Singer (2003), *supra* n. 2; Crandall and Singer (2010), *supra* n. 2.

have attempted to quantify the employment effects of changes in communications policy. All of these studies conclude that employment, both in and outside the communications industry, is highly responsive to capital expenditures by communications firms. Consequently, it is argued that, depending on the response of firms to regulatory interventions, public policy may have significant positive—or negative—employment effects.

In calculating employment effects, these studies rely heavily or exclusively on employment multipliers calculated by the U.S. Bureau of Economic Analysis' ("BEA") Regional Input-Output Modeling System ("RIMS II").[7] RIMS is a general equilibrium model of the economy sponsored by a federal government agency; and, unlike some private-sector models, its output is available at low cost to the research community. For these reasons, RIMS is a popular tool for the estimation of regional jobs impacts. Since RIMS has been extensively used, we attempt in this BULLETIN to provide evidence on employment effects using an entirely different methodology. Specifically, we estimate a type of "employment multiplier" directly using advanced time-series econometrics.[8]

This econometric approach has numerous benefits. For example, the Input-Output models provide annual employment effects.[9] In the econometric approach, however, we can estimate the immediate and lingering effects of a shock over time. Second, the causal connection between jobs and expenditures (at the margin) can be tested statistically. Third, the estimated multipliers can be compared to the multipliers used in prior studies, perhaps providing corroborate evidence.

Our approach, however, is not without important limitations. For example, our analysis is limited to "Information" sector capital expenditures and jobs. Clearly, capital expenditures in

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[6] Davidson and Swanson (2010), *supra* n. 2.

[7] http://www.bea.gov/regional/rims/index.cfm. Use of the RIMS multipliers to size employment gains and losses is attractive for many reasons: (a) RIMS is a general equilibrium model of the economy, so it can estimate employment effects for the entire economy of expenditures in just one sector; (b) the multipliers are calculated by a government agency and thereby are unaffected by any alleged researcher bias; and (c) these numbers can be looked up rather than calculated or estimated directly, thereby making it easier for researchers to produce estimates of employment effects.

[8] H. S. Rosen and V. K. Mathur *An Econometric Technique Versus Traditional Techniques for Obtaining Regional Employment Multipliers: A Comparative Study*, 5 ENVIRONMENT AND PLANNING 273-282 (1973).

[9] E. Ehrlich, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)*, U.S. Department of Commerce, Economics and Statistics Administration (1997) (available at: http://www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf) ("RIMS II, like all I-O models, is a 'static equilibrium' model, so impacts calculated with RIMS II have no specific time dimension. However, because the model is based on annual data, it is customary to assume that the impacts occur in 1 year. For many situations, this assumption is reasonable (at 8).")

communications will create employment opportunities outside of the Information sector, so we suspect our "multipliers" could be smaller than those found using RIMS or other Input-Output models. Consequently, our directly-estimated (Information sector) multipliers are probably conservative estimates relative to those found in these prior studies.[10] We look to other studies, such as Bivens (2003),[11] for factors to extend our employment multipliers to the entire economy. Also, data on the Information sector used here includes more than just telecommunications industry expenditures and employment (e.g., broadcasting and publishing). We make some effort to assess the impacts of such limitations, but the reader should keep these caveats in mind.

III. The Multiplier Method

The standard procedure in "jobs studies," including those mentioned above, is to assume that policy affects jobs *indirectly* via capital expenditures.[12] That is, a policy change leads to either more or less investment by firms and, in turn, this change in expenditure is what leads to more or fewer jobs.[13] More formally, let the number of jobs of interest be J, and let capital expenditures be E (which we measure in millions of constant-value dollars).[14] For some assumed change in policy, we have a change in expenditures (ΔE), and then a subsequent (and implied) change in jobs (ΔJ):

$$\Delta Policy \rightarrow \Delta E \rightarrow \Delta J \;, \tag{1}$$

In most cases, the relationship between jobs and expenditures is measured by the RIMS multipliers (or multipliers from some other Input-Output model such as IMPLAN), so that

$$\Delta J = m \cdot \Delta E \;, \tag{2}$$

where m is a "multiplier" that relates changes in jobs to changes in capital (or other) expenditures (where $m \geq 0$). From Expressions (1) and (2), we see that estimating a "jobs delta"

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10 Some multipliers measure the number of "indirect" jobs associated with the number of "direct" jobs. *See* J. Bivens, *Updated Employment Multipliers for the U.S. Economy*, Economic Policy Institute Working Paper (2003) (available at: http://www.epi.org/page/-/old/workingpapers/epi_wp_268.pdf).

11 Bivens, *id*.

12 Some Input-Output models derive employment effects from changes in industry revenues. *See, e.g.*, Bazelon, *supra* n. 2.

13 The jobs effect of spending is not limited to capital expenditures, though these studies focus only on investments rather than total spending. Public policy can certainly impact operating expenses, so the focus on capital expenses is too narrow.

14 Bazelon, *supra* n. 2.

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involves two key inputs: (1) how big is the expenditure change?, and (2) what is the relationship between jobs and expenditures? On the first, it is impossible to size the investment effect before specific rules are written, litigated, and "digested" by the industry.[15] As such, researchers typically consider a range of expenditure changes. In some cases, *ex post* analysis may be used to size potential investment consequences of particular types of regulatory intervention. This tact was employed, for example, in the Phoenix Center paper, *Using Auction Results to Forecast the Impact of Wireless Carterfone Regulation on Wireless Networks.*[16] In that paper, results from the 700MHz auction conducted in 2008, were exploited to estimate the effect of the network neutrality obligations imposed on the C Block of that spectrum. Then, using theory and empirics, the significantly reduced auction price for that block was used to size potential investment reductions from an expansion of that policy to the entire wireless industry. The predicted investment effects were sizeable, reducing wireless investment by some $50 billion over a decade.

On the latter, the multiplier "*m*" is typically taken from Input-Output models. In Davidson and Swanson (2010), for example, it is reported that a change of 100,600 jobs would result from a change in capital expenditures of $6.08 billion. The jobs impact is derived by using a RIMS multiplier that is equal to about 16.5 jobs per million in expenditures ($\Delta J/ \Delta E = 100600/60800 \approx 16.5$). The multipliers from a number of recent studies are summarized in Table 1. Crandall et al. (2003; 2010), CWA (2009), and Davidson and Swanson (2010) all rely exclusively on RIMS (Type II) multipliers. The difference between Crandall et al. (2003) and (2010) is driven by an increased variety of industry-specific multipliers that were updated subsequent to the earlier study. Davidson and Swanson (2010) rely on Crandall and Singer (2010) for the size of the multipliers so, by implication, uses RIMS. CWA (2009) expressly uses RIMS multipliers. Bazelon (2010) uses the IMPLAN Input-Output model for the computation of employment effects.

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[15] Empirically, sizing the investment effect requires establishing the counter-factual investment level. G. S. Ford, *Finding the Bottom: A Review of Free Press's Analysis of Network Neutrality and Investment*, PHOENIX CENTER PERSPECTIVE NO. 09-04 (October 29, 2009) (available at: http://www.phoenix-center.org/perspectives/Perspective09-04Final.pdf).

[16] *Supra* n. 2.

Table 1. Multipliers from Recent Studies

Study[17]	ΔE	ΔJ	m
Crandall … (2003)	$3.20B	58,043	18.1
CWA (2009)	$5.00B	97,500	19.5
Bazelon (2010)	$20.2	275,358	13.6
Crandall … (2010)	$30.4B	509,000	16.7
Davidson … (2010) A	$6.08B	100,600	16.5
Davidson … (2010) B	$48.5B	960,081	19.8

Notes: Bazelon based on 5-year average.

The multiplier approach indicates very large employment effects from the expenditures of communications firms, with the takeaway being that public policy must seriously evaluate the likely investment, and thus employment, effects of regulatory policies. Since all of these earlier studies rely, almost exclusively, on Input-Output multipliers, there is little to gain from applying that approach again. Therefore, in this BULLETIN we present an alternative method for sizing employment effects. We make no claims about the legitimacy of the Input-Output multiplier approach, but simply offer an alternative.

IV. Econometric Approach

Looking back to Expression (2), it seems, given data on J and E, that it should be possible to get an estimate of m (for some sectors) directly from historical data. We do so here. It is also possible not only to size m, but to test statistically whether or not changes in expenditures (ΔE) can be said to "cause" changes in employment (ΔJ). Moreover, with appropriate time series techniques, it is possible to estimate the capital expenditure and employment effects over extended periods of time of a shock, and to evaluate a shock of interest, such as a change in regulation. We view this econometric analysis as an alternative to, and potentially corroborative procedure for, the Input-Output multipliers as a means by which to size employment effects from capital expenditures in the communications industry.

A. *Data*

To begin, we build a sample from the available data. First, we considered the availability of employment data. The Bureau of Labor Statistics ("BLS") provides industry-specific employment data, but the availability of historical data depends on the industry of interest. Data on the "Information" sector (NAICS 51), which includes telecommunications, cable, broadcasting, publishing, and data processing, is available annually back to 1939. More narrow industry classifications only have about twenty years of data. Consequently, we use data on the

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[17] Crandall and Singer (2003), *supra* n. 2 at Table 5, Year 2010; CWA (2009), *supra* n. 4 at 1; Crandall and Singer (2010), *supra* n. 2 at 3; Davidson and Swanson (2010), *supra* n. 2 at 46-8; Bazelon (2010), *supra* n. 2 at Table 4.

Information sector more broadly to maintain a larger sample. Investment data (*E*) is provided in the BEA's Fixed Assets Tables.[18] We match the investment figures to the employment data, thereby including BEA Industry Codes 5110, 5120, 5130, and 5140. The investment data is available through year 2008. In 2007, total investment in this sector was $126.5 billion. Telecommunications and broadcasting firms (BEA Code 5130) accounted for about $100 billion (80%) of this total, so, despite the broad definition of the Information sector, most of the expenditures are from traditional telephone and cable companies. We convert the *nominal* "Investment" data to *real* values using the Producer Price Index ("PPI") as provided by BLS.[19] All values are expressed in 2009 dollars to aid in interpreting the results. While we have data going back to 1939, we restrict our analysis to the last forty years to help support the assumption of parameter stability. The time frame covered is 1969 through 2008.[20]

B. *Data Issues*

We are dealing with time series data, so standard least squares econometric approaches are unlikely to be valid. Some preliminary evaluation of the properties of the data is required prior to choosing the estimation approach. First, we need to evaluate whether the two series are stationary. We do so using the Augmented Dickey-Fuller Test ("ADF"). The results, including a test version with a constant term ("ADFc") and a constant term and trend ("ADFτ"), are summarized in Table 2. The two variables are found to be stationary in first differences.[21]

Second, we evaluate whether the two series have a cointegrating relationship. If so, then a long-run relationship exists between the two. This long-run dependency is important for evaluating the employment effects through time. As shown in Table 2, the Engle-Granger, Hausman-Type (Choi et al., 2008), and *H*(*p*, *q*) tests proposed by Park (1992) indicate that the two series are, in fact, cointegrated.[22]

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[18] http://www.bea.gov/national/index.htm#fixed.

[19] http://www.bls.gov/ppi.

[20] We also estimated the model with a shorter sample covering the last thirty years to evaluate the robustness of our findings. The results were very similar.

[21] This is also true for a shorter sample of thirty years.

[22] R. F. Engle and C. W.J. Granger, *Co-integration and Error Correction: Representation, Estimation, and Testing*, 55 ECONOMETRICA 251-276 (1987). Critical values (5%) are generated for 40 observation case by 100,000 Monte Carlo simulations; C. Choi, , L. Hu, and M. Ogaki, *Robust Estimation for Structural Spurious Regressions and a Hausman-type Cointegration Test*, 142 JOURNAL OF ECONOMETRICS 327-351 (2008); J.Y. Park, *Canonical Cointegrating Regressions*, 60 ECONOMETRICA 119-143 (1992).

Table 2. Statistical Properties of the Data

Aug. Dickey-Fuller Tests.		ADFc	ADFτ
Investment	Level	-1.342	-3.155
	Differenced	-4.002*	-4.034*
Employment	Level	-1.512	-2.395
	Differenced	-3.434*	-3.490*
Cointegration Tests		Statistic	Cointegrated?
Engle-Granger Test		-4.1824	Yes
Hausman-Type Test		1054.4	Yes
H(*p*,*q*) Test	H(0,1)	0.0875	Yes
	H(1,2)	0.3694	Yes
	H(1,3)	2.8988	Yes

* Statistically significant at the 5% level.

Given the results summarized in Table 2, we conclude that the employment and expenditure series are difference stationary random variables (that is, they are individually I(1)) and are cointegrated. Our estimation strategy proceeds accordingly.

C. *Estimation Details*

The details of the econometric estimation strategy are as follows. Let $y_t = [y_{1,t} \quad y_{2,t}]'$ be a vector of difference stationary random variables where $y_{1,t}$ and $y_{2,t}$ denote the number of information industry jobs (*J*) and real capital expenditures (*E*) in the same industry at time t, respectively. All variables are measured in natural logarithms. We assume that $y_{1,t}$ and $y_{2,t}$ are cointegrated with a cointegrating vector $\gamma = [1 - \beta]'$; that is, jobs (*J*) and expenditures (*E*) share a stable long-run relationship. For instance, if β equals 0.5, a 10% decrease in expenditures results in a 5% decrease in jobs in the long-run. Then, jobs and expenditures have the following triangular representation (Phillips, 1991):[23]

$$y_{1,t} = \alpha + \beta y_{2,t} + \varepsilon_t \tag{3}$$

$$\Delta y_{2,t} = \delta + u_t, \tag{4}$$

where Δ is the difference operator, α is an intercept, δ denotes a drift, ε_t and u_t are mean-zero white noise processes. The cointegrating parameter β can be estimated by the (static) least squares estimation ("SOLS"). However, the least squares estimator $\hat{\beta}_{LS}$ is asymptotically biased and inefficient. Furthermore, its asymptotic distribution is non-normal.[24] Therefore,

[23] P. Phillips, *Optimal Inference in Cointegrated Systems*, 59 ECONOMETRICA 283-306 (1991).

[24] *See* J. Stock, *Asymptotic Properties of Least-Squares Estimators of Cointegrating Vectors*, 55 ECONOMETRICA 1035-1056 (1987) and Phillips (1991), *id.*, for details.

statistical inference based on the least squares estimator may not be reliable. Recognizing these potential problems, we employ two alternative estimators for the cointegrating vector: (i) Park's (1992) CCR method and (ii) Stock and Watson's (1993) dynamic Ordinary Least Squares ("DOLS") estimator.[25] These estimators are more efficient and perform better than the least squares estimator in finite samples.

Given the cointegrating vector estimate for $\gamma = [1 \text{ - } \beta]'$ from (3) and (4), we construct the following bivariate vector error correction model ("VECM"). Abstracting from deterministic components,

$$\Delta y_t = \rho\gamma' y_{t-1} + \sum_{j=1}^{k} \theta_j \Delta y_{t-j} + C e_t \tag{5}$$

where $\rho = [\rho_1 \;\; \rho_2]'$ is a 2×1 speed of convergence parameter vector, C is a matrix that defines the contemporaneous structural relationship among employment and investment expenditures, and $e_t = [e_{1,t} \;\; e_{2,t}]'$ is a vector of mutually orthogonal structural shocks to these variables. We interpret $e_{2,t}$ as a structural shock that is caused by some external events that disturb investment expenditures but not employment. However, we allow $e_{2,t}$ to have an immediate effect on jobs.[26] For example, $e_{2,t}$ may be interpreted as a policy change that may result in a decrease in firms' capital expenditures, which may result in a job loss in that industry as firms re-optimize their production with reduced capital expenditures.

To study the effect of $e_{2,t}$ on jobs and investment expenditures in the short- and long-run, we employ the generalized impulse-response analysis based on our bivariate VECM described in Equation (3).[27] For this purpose, we rewrite Equation (5) as the following state-space representation:

$$z_t = F z_{t-1} + \xi_t \tag{6}$$

where

$$z_t = [y_t \;\; y_{t-1} \;\; \dots \;\; y_{t-k}]', \tag{7}$$

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[25] Park (1992), *supra* n. 22; J. H. Stock and M. W. Watson, *A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems*, 61 ECONOMETRICA 783-820 (1993).

[26] This happens when the (1,2)th element of C has a non-zero value.

[27] H. Pesaran and Y. Shin, *Generalized Impulse Response Analysis in Linear Multivariate Models*, 58 ECONOMIC LETTERS 17-29 (1998).

$$F = \begin{bmatrix} \vartheta_1 & \vartheta_2 & \cdots & \vartheta_{k+1} \\ & & & 0 \\ & I_{2k} & & \vdots \\ & & & 0 \end{bmatrix}, \quad (8)$$

$$\xi_t = [Ce_t \;\; 0 \; \ldots \; 0]', \quad (9)$$

and

$$\vartheta_1 = I_2 + \rho\gamma' + \theta_1, \quad (10)$$

$$\vartheta_j = \theta_{j+1} - \theta_j, j = 2, \cdots, k, \quad (11)$$

$$\vartheta_{k+1} = -\theta_k, \quad (12)$$

and I_p is the p-dimension identity matrix. The r^{th} period impulse-response functions, then, are obtained by,

$$(S'F^r S)C \quad (13)$$

where $S = [I_2 \;\; 0 \; \cdots \; 0]'$ is a $2(k + 1)\times3$ selection matrix and the contemporaneous matrix C can be obtained by the Choleski factor of the least squares variance-covariance matrix of Expression (5).[28] Our forecast of the information job changes due to the real capital expenditure shock and other estimates is mostly obtained from the estimates for Expression (13).

V. Results

Our analysis was conducted using a purpose-built program written in the GAUSS language, although many of our estimations are supported by popular statistical packages.[29] Once the relevant parameters are estimated, it is possible to simulate the effects on jobs of a shock to capital expenditures. We do so here, but first we address the question of causality between expenditures and jobs, or vice versa, using the standard Granger Causality test.[30] Note,

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28 With regards to the responses of employment to a capital expenditure shock, the generalized impulse-response function coincides with the orthogonalized impulse-response function with expenditures the first in the ordering. For details, *see* H. Kim, *Generalized Impulse Response Analysis: General or Extreme?* MUNICH PERSONAL REPEC ARCHIVE WORKING PAPER NO. 17014 (2009)(available at: http://mpra.ub.uni-muenchen.de/17014/1/gircheck09.pdf).

29 Our code is available on request.

30 It should be noted that Granger causality does not mean actual causality. When x Granger causes y, it means that x provides additionally useful information other than the past values of y to predict y.

however, that the Granger test is short-run in nature and our cointegration analysis indicates that the two series do have a long-run relationship.

A. *Short-Run Granger Causality*

In order to evaluate short-run causality, we apply the standard approach of bivariate Vector Autoregression ("VAR"). Given that our series are I(1), we use first-differenced data and estimate the following general equations

$$\text{Expenditure } \textit{Granger causes} \text{ Jobs: } \Delta J_t = f(\Delta J_{t-1}, \Delta E_{t-1}), \quad (14)$$

$$\text{Jobs } \textit{Granger Cause} \text{ Expenditure: } \Delta E_t = f(\Delta J_{t-1}, \Delta E_{t-1}), \quad (15)$$

where the one-period lag is based on minimizing the Bayesian Information Criterion ("BIC"). The F-statistic on the null hypothesis that *Expenditures does not cause Jobs* is 7.36, which is statistically significant at the 5% level (the null is rejected). Therefore, the evidence suggests that there is a causal relationship flowing from changes in capital expenditures to employment. In contrast, we cannot reject the null hypothesis that *Jobs does not cause Expenditure*, with an F-statistic of only 0.51. As such, we have a one-way causal relationship, in a Granger causality sense, flowing from changes in capital expenditures to jobs. We find these results sensible, but note this analysis ignores the cointegrating relationship between the two series.

B. *Vector Error Correction Model* ("*VECM*")

We begin our examination of the VECM results by looking at Table 3, which provides our speed-of-convergence estimates. This information provides measures of the degree to which each variable (jobs and investment) contribute to the adjustment process to the underlying, long-run equilibrium relationship. To interpret these results, recall that there exists a long-run equilibrium relationship between investments and Information sector jobs. When an external shock of some kind disturbs this balance, a process of adjustment occurs in which both investments and job levels change over time until the equilibrium relationship is restored.

Table 3. Speed of Convergence Estimates

	Estimates	*Standard Error*
E (ρ_1)	1.3323*	0.5550
J (ρ_2)	-0.1614	0.1522

Notes: (i) The point estimates for ρ and associated standard errors are reported; (ii) The superscript * denotes a rejection of the unit-root null hypothesis at the 5% significance level; (iii) Each estimate has a correct sign that implies that both *E* and *J* contribute to the adjustment process toward the long-run equilibrium. However, *E* plays a more dominant role that that of *J*, because its speed of adjustment parameter is relatively bigger and significant at the 5% level.

However, the speed at which these two variables change is quite different. Table 3 shows that the primary source of such adjustments is changes in capital investment expenditures. This is unsurprising: capital investment is volatile and flexible, when compared to employment, especially for sectors that offer higher pay and skilled employment.

Table 4. Cointegrating Vector Estimation Results

	Constant (*a*)	*CAPEX* (*β*)
SOLS	9.9478 (0.1829)	0.4259 (0.0161)
DOLS	9.8409 (0.0344)	0.4361 (0.0344)
CCR	9.6897 (0.1461)	0.4478 (0.0129)

Notes: (i) SOLS denotes a static ordinary least squares estimator; (ii) DOLS is the dynamic ordinary least square estimator proposed by Stock and Watson (1993); (iii) CCR is Park's (1992) canonical cointegrating regression estimator; (iv) The quadratic spectral kernel with automatic bandwidth selection was used to obtain the long-run variance matrix; (v) Standard errors are reported in parentheses. All variables are significant at the 5% level.

Next, we turn to our primary findings and focus: the cointegrating vector estimation results reported in Table 4. We offer three different estimates based on three statistical criteria: ordinary least squares (SOLS), dynamic ordinary least squares (DOLS) (Stock and Watson, 1993),[31] and canonical cointegrating regression (CCR) (Park, 2002).[32] The point estimates all appear quite similar, although this must be regarded as primarily a fortuitous result: SOLS is not statistically appropriate. These coefficients provide estimates of the long-run effects of shocks on the equilibrium values of the variables. In particular, referring to the CCR finding for example, our analysis indicates that a 10% reduction in capital expenditures leads, in equilibrium, to an approximately 4.5% reduction in Information sector jobs, when all feedbacks

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31 Stock and Watson (1993), *supra* n. 25.

32 Park (1992), *supra* n. 22.

between these variables are taken into account. This is a very significant effect. The reason for the large effect is that a shock to capital expenditures in one period affects employment and capital spending in the next period, which in turn affects these variables going forward, and so on. This complex interdependence over time is precisely the kind of information that is potentially useful, but is never available from ordinary multiplier analysis.

C. *Simulating the Employment Effects*

Using the estimates from the VECM, we can conduct a variety of simulations to measure the effect on jobs from a change in capital expenditures. Our simulations assume a negative shock to capital expenditures (in 2009 dollars) ranging from 1% to 30%. In Table 5, the simulated reductions in capital expenditures are provided. Note that the assumption in the simulation is a one-time shock (a shift in the expenditure-time curve), but this reduction persists over time. Since each series is I(1) with drift, each series eventually recovers from the initial decline over time. When the shock is large, both expenditures and jobs decline for more than one period, after which they start to recover, following their stochastic trends in line with their cointegrating relation. Thus, a negative expenditure shock actually causes the level of jobs to fall in the short run. This employment shock is persistent despite the fact that over time secular growth in the economy raises employment. In other words, the economy exhibits lower levels of sector employment, compared to the no-shock case, indefinitely.

Table 5. Annual Real Investment Change (ΔE)
(Million of 2009 Dollars)

Shock Size	1 Year	5 Year	10 Year	20 Year	30 Year
1%	1,148	1,207	1,428	1,682	2,036
5%	5,626	5,914	6,985	8,231	9,965
10%	10,978	11,530	13,595	16,031	19,409
15%	16,068	16,862	19,850	23,420	28,360
20%	20,911	21,925	25,771	30,432	36,844
30%	29,899	31,298	36,676	43,368	52,505

The effects on jobs from these reductions in capital expenditures are summarized in Table 6. As expected, as the size of the shock increases, so does the magnitude of the job loss. For a 5% negative shock, job loss is estimated to be 31,537 jobs, whereas a 10% shock reduces employment by 62,741 jobs in the first year. In five years, that same 10% shock has reduced sector employment by 156,187 jobs (in the fifth year). Over the first five years, the average annual job loss is 128,628 jobs. (See the Appendix for annual changes.) It is important to remember these are Information sector jobs only; our estimates do not capture the employment (or capital expenditure) effects on other sectors. As such, the job-loss estimates here do not include the full extent of the expected job loss.

Table 6. Annual Employment Change from Shocks (Δ*J*)
(Information Sector Jobs Only)

Shock Size	1 Year	5 Year	10 Year	20 Year	30 Year
1%	6,334	15,991	15,265	16,654	18,134
5%	31,537	79,119	75,599	82,478	89,802
10%	62,741	156,189	149,404	162,994	177,477
15%	93,615	231,256	221,463	241,601	263,070
20%	124,163	304,381	291,815	318,343	346,629
30%	184,294	444,987	427,554	466,399	507,848

With the estimates of investment and employment changes, we can compute the jobs multipliers implied by the VECM. These multipliers are summarized in Table 7. To understand this table, one should note that the multipliers given refer to actual numbers of jobs lost per one million dollars in lost investments in the base year. Thus, for example, a 10% negative shock will, after say 5 years, result in an observed loss of 13.5 jobs per million dollars in lost investment. The non-monotonicity of these values, as can be observed in the Table, is a consequence of the relatively rich dynamic process of adjustment described earlier. Importantly, the most severe consequences of the loss in investment are seen to occur in the "middle term"—i.e., in the 3-5 year time horizon. However, the effects are persistent for a very long time.

Table 7. Annual Employment Multipliers
(Information Jobs Only)

Shock Size	1 Year	2 Year	3 Year	4 Year	5 Year	10 Year	20 Year	30 Year
1%	5.5	7.0	9.3	11.7	13.2	10.7	9.9	8.9
5%	5.6	7.2	9.5	11.9	13.4	10.8	10.0	9.0
10%	5.7	7.4	9.7	12.1	13.5	11.0	10.2	9.1
15%	5.8	7.6	9.9	12.3	13.7	11.2	10.3	9.3
20%	5.9	7.8	10.1	12.5	13.9	11.3	10.5	9.4
30%	6.2	8.2	10.6	12.9	14.2	11.7	10.8	9.7

D. *Indirect Job Impacts*

By nature of the data, the econometric analysis above estimates only the relationship between expenditures and employment in the Information sector of the economy. Surely, however, expansion in the information industries leads to employment in other sectors, including directly related industries such as manufacturing and construction, and indirectly in other industries benefitting from the higher incomes of employees. Using econometric methods to derive these additional jobs can be difficult, since we cannot simply change the employment data and assume that jobs in all sectors are driven by capital expenditures in the Information sector. We can offer, however, some evidence on employment effects in other sectors.

1. *Employment Multiplier Approach*

One option for sizing indirect jobs effects is to use the multiplier approach of Bivens (2003), where every one job in the communications sector is associated with 2.52 indirect jobs.[33] In the previous section, we calculated a five-year multiplier of about 9.5. Given Bivens' (2003) estimate of 2.54 jobs per communications job, the total effect on employment from a shock is about 24 jobs per million of investment.[34] Comparing this value to those in Table 1, we see that the multipliers used in some recent studies are, if anything, conservative. Table 8 adjusts our multipliers to account for these indirect effects.

Table 8. Annual Employment Multipliers
(Information and Other Jobs)

Shock Size	1 Year	2 Year	3 Year	4 Year	5 Year	10 Year	20 Year	30 Year
1%	13.9	17.6	23.4	29.5	33.3	27.0	24.9	22.4
5%	14.1	18.1	23.9	30.0	33.8	27.2	25.2	22.7
10%	14.4	18.6	24.4	30.5	34.0	27.7	25.7	22.9
15%	14.6	19.2	24.9	31.0	34.5	28.2	26.0	23.4
20%	14.9	19.7	25.5	31.5	35.0	28.5	26.5	23.7
30%	15.6	20.7	26.7	32.5	35.8	29.5	27.2	24.4

Note: Multiplies multipliers from Table 7 by 2.52 based on Bivens (2003).

In Table 9, we provide the employment changes from the expenditure shocks including these indirect effects. The values in Table 9 are computed simply by scaling the employment effects from Table 6 by the Bivens (2003) factor of 2.52. Comparing Table 9 to Table 6, we see that including indirect job loss results in significantly larger employment effects from expenditure shocks.

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33 Bivens (2003), *supra* n. 10.

34 *Id*.

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Table 9. Annual Employment Change from Shocks (ΔJ)
(Information Sector and Indirect Jobs)

Shock Size	1 Year	5 Year	10 Year	20 Year	30 Year
1%	15,962	40,297	38,468	41,968	45,698
5%	79,473	199,380	190,507	207,842	226,306
10%	158,107	393,591	376,501	410,747	447,245
15%	235,910	582,765	558,087	608,835	662,936
20%	312,891	767,035	735,371	802,219	873,510
30%	464,421	1,121,365	1,077,436	1,175,325	1,279,782

We note, however, that this calculation depends on the accuracy and continued relevance of the values provided in Bivens (2003). Bivens (2003) notes a number of conceptual problems with multipliers.[35] Nevertheless, the calculations in that paper are rather straightforward and may serve as a reasonable, albeit crude, estimate of economy-wide employment effects. Assuming Bivens (2003) overstates the multiplier by 40%, our estimates still support a multiplier of about 16.5 jobs per million in expenditure, as assumed by Davidson and Swanson (2010). So, even if Bivens (2003) is only remotely correct, the implied employment effects from our analysis will equal or exceed those from prior, multiplier-based studies.

2. *Econometric Analysis of Indirect Effects*

As stated above, given our underlying assumptions and approach, we cannot simply extend the VECM to all employment sectors. We can, however, selectively look at a few other industries with strong ties to telecommunications. For example, the BLS provides employment data on "Power and communication system construction (NAICS 23713)," though this series is available only since year 1990 (we label this jobs series as ΔJ^{PCSC}). Applying a simple VAR to the limited available data (17 periods), we find

$$\Delta J_t^{PCSC} = 0.04 - 0.35\Delta J_{t-1}^{PCSC} + 0.40\Delta E_{t-1} + e_t \,, \qquad (16)$$

where the coefficient on ΔE_{t-1} is statistically significant at the 5% level ($t = 3.2$), indicating a causal connection between capital expenditures in the Information sector and employment in the "power and communications system construction" sector (which is a component of the Construction Industry). Similarly, we can look at employment in "Communications Equipment (NAICS 3342)," which again is limited to data from 1990 through 2009. The estimated relationship is

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35 *Id.* at 5-6.

$$\Delta J_t^{CE} = 0.04 + 0.11\Delta J_{t-1}^{CE} + 0.31\Delta E_{t-1} + e_t\,, \tag{17}$$

Where, again, the null hypothesis of "no Granger causality" between ΔE and ΔJ is rejected (asymptotically).[36] These simple regressions are suggestive of employment effects outside the industry (which is hardly questionable to begin with), but we note that the data is very limited and this analysis should be viewed as exploratory in nature. The validity of the asymptotic statistical tests is questionable in such small samples. As we observed with the Information sector data, employment and capital expenditures have a long-run relationship and the econometric procedures should account for that fact. With such limited data, however, we do not apply the VECM to these series.

Moreover, we emphasize that our approach is *not* a general equilibrium one. By looking at one, or a few, sectors in isolation, one cannot make economy-wide forecasts. Over time, many resources do become employed somewhere, so job losses in one sector presumably trigger employment reallocation into other sectors. However, this process is by no means instantaneous, and the current high rates of unemployment in the U.S. illustrate the practical difficulty such reallocations entail.

VI. Corroboration with Prior Studies

Part of the motivation for this study was to compare our estimates of employment effects with those calculated using multipliers from Input-Output models. The multipliers from a few of the more recent studies are summarized in Table 1. Consider, for example, the study by Davidson and Swanson (2010). While numerous scenarios are provided in that study, one such scenario estimates that 152,400 jobs are lost per year (over the 2010-2015 period) for a $9.12 billion reduction in capital expenditures (implying a multiplier of 16.7, commensurate with the BEA Type II multiplier).[37] We choose this example because our multipliers vary by year and Davidson and Swanson (2010) provide a five-year average effect. Using the VECM to simulate the jobs reduction from the same $9.12 billion shock, we estimate about an 87,000 average annual job loss (over the five-year period) for the Information sector, implying a five-year average multiplier of 9.58. Adding in indirect jobs based on Bivens (2003), this multiplier increases to about 24.

Comparing these multipliers with those used in Davidson and Swanson (2010) (about 16.5), we see that the information-sector specific multiplier is smaller (about 9.5) but the total multiplier (about 24) is larger. Even if the total multiplier (based on Bivens (2003)) is overstated

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36 The t-statistic is 1.92 (Prob = 0.076).

37 Davidson and Swanson, *supra* n. 2 at 60.

by a significant amount, it appears that the findings of Davidson and Swanson (2010), and by reference Crandall and Singer (2010), are plausible if not conservative. This correspondence is encouraging, since our estimates are based on an entirely different methodology.

VII. Information Sector Jobs are Not Average Jobs

In the typical study of employment effects, jobs are discussed as if they were all alike. This is certainly not true across industries, even on average. In Table 10 below, communications industry jobs are compared to the typical private industry jobs in a number of policy-relevant dimensions. Communications jobs are divided into Information sector jobs, as defined for the analysis above, and telecommunications industry jobs, which is a subset of the Information sector. Most of the data is made available by the BLS.

Table 10. Employment Details by Industry

	Median Weekly Earnings (2009)	Union Membership (2009)	Unemployment (April 2010)
Telecommunications	$1,096	17.7%	8.7%
Information	$1,073	10.0%	9.4%
Private Industry	$753	7.2%	9.9%

Sources: www.bls.gov; www.unionstats.gsu.edu.

As shown in the first column of the table, median weekly earnings for Information sector employees are 42% higher than typical private sector jobs ($1,073 versus $753). Earnings in the more narrow telecommunications sector are slightly higher still, being 45% above the typical private sector job. This large difference is important when considering employment effects from either multiplier or econometric calculation. One telecommunications job lost is, in income terms, the equivalent of nearly 1.5 typical jobs. Our analysis above indicates a change of 10 telecommunications jobs per million in capital expenditures, but these jobs are equivalent, in income terms, to 15 average private sector jobs.

Given the income information in Table 10, it is possible to construct an "earnings effect" using the econometric simulations. If we assume the changes in jobs from Table 7 are typical jobs, then we can multiply the median earnings from Table 10 to get this earnings effect from the shock. (Since income is typically found to be log-normal, our calculation is a conservative one since the median is below the mean.)[38] Table 11 summarizes this calculation. The jobs numbers in Table 7 should be considered annual positions, but in Table 11 we accumulate the lost earnings over time. A 10% *negative* shock reduces employee income by $3.5 billion in the

[38] A. Chatterjee, S. Sinha, and B. Chakrabarti, *Economic Inequality: Is it Natural?*, 92 CURRENT SCIENCE 1383-1389 (2007); C. Kleiber and S. Kotz, STATISTICAL SIZE DISTRIBUTIONS IN ECONOMICS AND ACTUARIAL SCIENCES (2003).

first year, $36 billion by the fifth year, and $76.6 billion by the tenth year. Over the thirty-year horizon, Americans have lost $260 billion in income from the Information sector jobs as a result of the shock.[39]

Table 11. Accumulated Income Change from Shocks (Δ*J*)
(Billions, Information Sector Jobs Only)

Shock Size	1 Year	5 Year	10 Year	20 Year	30 Year
5%	$1.8	$18.2	$38.8	$83.2	$137
10%	3.5	36.0	76.6	164	260
20%	6.9	70.3	150	321	508
30%	10.3	103	219	471	744

In Table 12, we include the income lost from the indirect jobs. For this calculation, we add to the numbers in Table 11 the income lost from the indirect jobs, which we assume to be rated at the median earnings of all private sector jobs from Table 10. (Again, this approach is designed to render a conservative estimate of income loss.) From the table we see that a 10% income shock results in lost earnings of $99.6 billion over a five-year period. Thus, the indirect jobs increase lost income by about 177%.

Table 12. Accumulated Income Change from Shocks (Δ*J*)
(Billions, Information Sector and Indirect Jobs)

Shock Size	1 Year	5 Year	10 Year	20 Year	30 Year
5%	$4.89	$50.4	$107	$230	$364
10%	9.7	99.6	212	455	720
20%	19.1	195	414	890	1,406
30%	28.5	285	608	1,303	2,061

Information sector jobs differ from typical private-sector employment in other ways. In the final column of Table 10, the data show that employment in telecommunications has proven significantly more resilient to the business cycle than have other sectors, with unemployment well below the national average (8.7% versus 9.9%). Furthermore, union membership is much higher in telecommunications, with 17.7% of the workforce being unionized. This high rate

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[39] These calculations are based on 2009 dollars. We simply multiply weekly earnings by 52 and then multiply by the number of jobs lost (for Information sector jobs the annual income is $55,796). In some regards, this approach is likely to be conservative, but it is admittedly simplistic. *See* N. Rytina, *Comparing Annual and Weekly Earnings from the Current Population Survey*, 4 MONTHLY LABOR REVIEW 32-36 (1983)(available at: http://www.bls.gov/opub/mlr/1983/04/rpt2full.pdf).

compares with only 7.2% of private sector employees who are classified as union members. These differences may have significant public policy relevance.

VIII. Caveats

There are a number of important caveats, some mentioned above, to work of this type. Foremost is the obvious (though sometimes lost) point that while increasing capital expenditures and jobs in a bad economy are certainly worthy social goals of public policy, such goals nonetheless must be accomplished in an economically efficient manner. For example, we could increase employment in the telecommunications sector by prohibiting the use of the digital switch and return to the days of operator-based switching, or we could forbid the use of heavy machinery to dig trenches, thereby creating many jobs for shoveling dirt. Indeed, it is quite possible for regulation or legislation to promote inefficiently high levels of capital expenditures and/or labor, thus reducing overall welfare.[40] For example, rate-of-return regulation has been criticized for its tendency to promote excess capital investment and inefficient capital-to-labor ratios.[41]

Consider a very simple example on this point. Say there are two mutually exclusive investment options (so only one is needed). The first generates 100 units of social benefit, 50 units of private benefit, and requires an investment of 10 units. The second has 80 in social benefit, 40 in private benefit, and the required investment is 20 units. The private payoff for both projects is positive (40 for the first, 20 for the second), and the social benefit is larger for the first than it is the second (90 versus 60). The firm would do either project since both have positive returns, but of course the firm prefers the first project with its larger payoff. As such, if regulation precludes the first option, then the firm undertakes the second project with its lower payoff and by doing so incurs twice the capital expenditure as was privately and socially desirable (20 versus 10). By capital expenditures standards, the regulation appears desirable and has a "good" outcome. Yet, the regulation has instead forced a less socially desirable project. As shown by this example, regulation that increases capital expenditures need not be socially beneficial, demonstrating the basic fact that great care should be exercised when discussing the relationship between regulation and capital expenditures and, in turn, labor.

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[40] *See, e.g.*, G. S. Ford, T. M. Koutsky and L. J. Spiwak, *The Efficiency Risk of Network Neutrality Rules*, PHOENIX CENTER POLICY BULLETIN No. 16 (May 2006)(available at: http://www.phoenix-center.org/PolicyBulletin/PCPB16Final.pdf); R. Clarke, *Costs of Neutral/Unmanaged IP Networks*, 8 REVIEW OF NETWORK ECONOMICS, Article 5 (2009) (available at: http://www.bepress.com/rne/vol8/iss1/5).

[41] H. Averch and L. Johnson, *Behavior of the Firm Under Regulatory Constraint*, 52 AMERICAN ECONOMIC REVIEW, 1052-70 (1962); W. Baumol and A. Klevorick, *Input Choices and Rate-of-Return Regulation: An Overview of the Discussion*, 1 BELL JOURNAL OF ECONOMICS AND MANAGEMENT SCIENCE 162-190 (1970); E. Zajac, *Note on "Gold Plating" or "Rate Base Padding"*, 3 BELL JOURNAL OF ECONOMICS AND MANAGEMENT SCIENCE 311-315 (1972); C. Needy, The *Gold-Plating Controversy: A Reconciliation*, 45 SOUTHERN ECONOMIC JOURNAL 576-582 (1978).

Furthermore, capital is portable, so a reduction in investment in one sector may simply shift much of that investment to another sector, presumably having employment impacts there as well. As a matter of policy, the relevant question may be the net effect on capital and employment, not just the partial effects in a single industry or sector. The communications sector is unique in many respects, such as its role as a general-purpose technology and its potential for significant spillovers. Thus, capital in the Information sector may have a higher social payoff than capital in other sectors, but a simple jobs analysis fails to take this into account.

Finally, all our estimates are based on the available data, which may be argued to be imperfect in some way. This caveat is inescapable when doing empirical work, but still worthy of mention.

IX. Conclusion

In this BULLETIN, we estimate the relationship between investment and employment in the Information sector. Earlier studies addressing this same topic typically rely on multipliers from Input-Output models such as the Regional Input-Output Modeling System ("RIMS"), which is often sensible since these models are designed for the purpose of measuring regional output and employment impacts. As an alternative, we use econometrics and historical data to quantify the effect on jobs of changes in investment in the sector. Our findings largely corroborate the multiplier approach in that we find information-sector multipliers of about 10. Adding in indirect employment effects could more than double this figure, suggesting the RIMS multipliers may be conservative.

We also demonstrate that jobs in the information sector are not typical. Median earnings in the sector are 45% higher than the typical private sector job, so a single information job gained or lost is equal to about 1.5 average jobs gained or lost. In the telecommunications sector, unemployment is well below the national average, suggesting sector employment is robust to the business cycle. Also, union employment in telecommunications is more than twice the rate for the economy generally.

In all, we concur with earlier studies that policy-induced shocks to capital spending may have sizeable and long-term employment effects. If jobs are viewed as a legitimate public policy concern, then policymakers should seek to encourage the expansion of the sector and avoid interventions that threaten to reduce investment.

Appendix: Annual Employment Change from Shocks

		Reduction in Jobs from Forecast Trend			
Year	Forecast	Δ*E* = -5%	Δ*E* = -10%	Δ*E* = -20%	Δ*E* = -30%
1	2,983,999	-31,537	-62,741	-124,163	-184,293
2	3,005,835	-57,875	-114,636	-224,899	-330,961
3	3,020,944	-75,468	-149,054	-290,754	-425,462
4	3,033,692	-81,351	-160,521	-312,545	-456,529
5	3,051,375	-79,119	-156,189	-304,381	-444,987
6	3,075,903	-74,621	-147,432	-287,800	-421,437
7	3,104,791	-71,881	-142,096	-277,688	-407,075
8	3,134,581	-71,894	-142,140	-277,837	-407,378
9	3,163,204	-73,623	-145,536	-284,378	-416,830
10	3,190,423	-75,599	-149,404	-291,815	-427,554
11	3,217,030	-76,952	-152,064	-296,940	-434,967
12	3,243,894	-77,611	-153,368	-299,484	-438,692
13	3,271,431	-77,931	-154,002	-300,758	-440,602
14	3,299,604	-78,274	-154,690	-302,125	-442,652
15	3,328,176	-78,812	-155,757	-304,228	-445,747
16	3,356,942	-79,526	-157,167	-306,976	-449,768
17	3,385,828	-80,306	-158,710	-309,980	-454,163
18	3,414,873	-81,075	-160,221	-312,925	-458,467
19	3,444,144	-81,793	-161,640	-315,695	-462,519
20	3,473,687	-82,478	-162,994	-318,343	-466,399
21	3,503,517	-83,159	-164,344	-320,978	-470,262
22	3,533,622	-83,856	-165,722	-323,672	-474,214
23	3,563,989	-84,573	-167,139	-326,440	-478,274
24	3,594,610	-85,303	-168,586	-329,268	-482,414
25	3,625,486	-86,047	-170,051	-332,123	-486,596
26	3,656,624	-86,789	-171,519	-334,988	-490,794
27	3,688,026	-87,535	-172,988	-337,865	-495,005
28	3,719,702	-88,283	-174,470	-340,757	-499,247
29	3,751,653	-89,041	-175,965	-343,680	-503,526
30	3,783,878	-89,802	-177,477	-346,629	-507,848