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WAGE INEQUALITY AND OFFSHORING: ARE THEY RELATED?

KOUSHIK GHOSH, PETER J. SAUNDERS, AND THOMAS TENERELLI

Abstract

The objective of this paper is to investigate the impact of offshoring on wage inequality and labor productivity in the U.S. Short-run and long-run data tests are undertaken to analyze the relationship among offshoring, wage inequality, and labor productivity in the U.S. Cointegration tests indicate that these three variables are related in the long-run. The main contribution of this paper lies in its focus on the short-run investigation of the relationship among these three variables. This investigation is conducted using the vector error correction (VEC) testing framework. VEC tests indicate that offshoring has had a statistically significant impact on both labor productivity and wage inequality in the U.S.

Key Words: *offshoring, wage inequality, and labor productivity.*

JEL Classification*: F16*

I. INTRODUCTION

Analyzing and explaining the causes of wage inequality have long been focuses of economic inquiry. Although this issue has been addressed thoroughly in both theoretical discussions and empirical research, there is no commonly accepted explanation of the causes of changing wage inequality. The beginning of this discussion can be traced to the writings of Adam Smith (1776) who outlined how trade and specialization can transform societies. Since the first industrial revolution, which transformed agricultural societies to manufacturing ones, there have been two more such events. The second revolution was characterized by a movement from manufacturing to service industries. Currently most countries are experiencing the third industrial transformation which is characterized by, among other things, offshoring (commonly referred to as outsourcing). One of the key concerns of this latest economic development is its impact on income distribution and wage inequality in all of the countries operating in the global market place. While the analyses of the effect of increased offshoring on wage inequality are potentially

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ambiguous, this issue remains vigorously alive due to a paucity of empirical studies and theoretical discussions.

Offshoring typically involves trade in tasks and goods among participating countries. Trade in tasks occurs when one or more portions of the production process are offshored. This type of international trade can have a negative or positive impact on the wages of low-skilled workers in countries where tasks are outsourced abroad. Grossman and Rossi-Hansberg (2006 and 2008) defined this issue elegantly. Their analysis invites further empirical research that can shed additional light on the impact of offshoring on wage inequality. The authors point out that trade in tasks rather than trade in goods characterizes the above mentioned new industrial revolution. They suggest that such trade is not necessarily detrimental to wages of low-skilled workers. The authors also point out, however, that their empirical analysis is relatively crude and should be fine-tuned.

Clearly, controversies surround the issue of the impact of offshoring on income inequality in countries that participate in international trade. In order to assess this impact, it is important to outline initially the key features of the new industrial revolution that is characterized by trade in tasks. Offshoring has important effects on U.S. imports and, thereby, it can impact income distribution in the U.S. It affects not only the volume of U.S. imports, but also their content. Using OECD data, Grossman and Rossi-Hansberg (2006 and 2008) have calculated the estimated share of imported inputs in total inputs used by all goods-producing sectors in the United States. Their estimates indicate that the share of imported inputs in the gross output of these sectors has been growing steadily over the last three decades. They find evidence of an acceleration of this trend after 1995.

Trade in tasks, that is to say offshoring, has played an increasingly important role in international trade.[1] This type of trade can have a considerable impact on the wages of skilled and unskilled workers. The primary objective of this paper is to analyze the impact of offshoring on income inequality in the U.S. This category of trade is likely to grow even more in the coming years, as more "routine" cognitive tasks are increasingly exported overseas [Autor, D., Levy F., and Murnane, R (2003)]. Offshoring has become an important feature of today's global economy, and it will continue to be so. How offshoring affects wages and income inequality in trading countries is unclear. Only empirical research, such as the present study, can provide some answers to this critically important and not yet resolved issue.

In order to understand better the impact of offshoring on income inequality, it is also essential to analyze the potential effects of offshoring on the labor supply. Leamer (2006) and others have described how increased opportunities for offshoring can lead to an expansion in the world supply of low-skilled labor. Citing the properties of the Heckscher-Ohlin (1933) model with incomplete specialization, Grossman and Rossi-Hansberg (2006 and 2008) develop a simplified version of their general equilibrium model that eliminates the relative price effect of trade. The two authors suggest that the expansion in the world supply of low-skilled labor may not affect factor prices, since factor growth can be accommodated without an impact on factor prices. Thus, there need not be a depressing effect on domestic wages of low-skilled workers, even if Leamer's (2006) hypothesis is correct.

Grossman and Rossi-Hansberg (2006 and 2008) outline a new paradigm in trade theory. As mentioned previously, the two authors suggest that international trade theory should focus on trade in tasks rather than trade in goods. Given this assertion, they investigate the impact of offshoring on wages of high-skilled and low-skilled labor. The two authors suggest that as the cost of offshoring decreases, firms move L-tasks (low-skill tasks) abroad, thus increasing both productivity (due to the decreased costs associated with the already offshored L-tasks) as well as the supply of low-skilled labor in the economy. Productivity improvement is primarily due to the decreased costs associated with the already offshored L-tasks. The authors further suggest that the positive productivity effect on demand for low skilled labor that raises their wages may indeed dominate the negative labor supply effect on these wages. This would then imply that the wages of low-skilled workers would not be affected negatively by the decrease in offshoring costs. This would also mean that offshoring would not worsen wage inequality. In their 2006 empirical analysis, the authors conclude that "the data leave room for a positive effect of offshoring on wages" (p. 30). These observations notwithstanding, the authors point out that there are several omitted factors in their analysis, and that their conclusions "be taken with a grain of salt until a more thorough empirical study can be performed." (p. 31).

In this paper, we accept the above stated empirical challenge and subject the Grossman and Rossi-Hansberg (2006 and 2008) hypothesis to empirical tests using both long-run and short-run analyses of wage and trade data. The novelty of our empirical inquiry lies not only in its focus on analyzing the long-run as well as short- run relationship among wage inequality and international trade, but also on its analysis of the impact of offshoring on labor productivity. Therefore, the present paper provides empirical evidence for both key issues raised by Grossman and Rossi-Hansberg: the effects of offshoring on labor productivity and on wage inequality.

There is one additional important objective of our present research. Our paper is an extension and a further refinement of our previously published research on the relationship between trade, wage inequality, and productivity in the U.S. [Ghosh, Saunders, and Biswas (2000), and Ghosh, Saunders, and Biswas (2002)]. The objective of our 2000 paper was to investigate the relationship between wage differentials of unskilled and skilled labor (approximated by the differences between the median incomes of males who completed high school and the median incomes of four-year college graduates) and trade (approximated by net exports). We found that trade in the U.S. is negatively impacted by wage inequality. In our 2002 paper, we expanded our investigation into the relationship between trade and income inequality in the U.S. by including the effects of labor productivity (measured by the output per hour of all persons in the non-farm business sector) on these variables.

We found that while wage differentials and net exports had a statistically significant impact on labor productivity, wage inequality was not impacted by the combined impact of trade and labor productivity. While our present paper is a natural extension of our previously published research, it adds two new important dimensions to our previous empirical analyses. First, the focus is on analyzing the effects of offshoring on wage inequality and labor productivity.[2] Second, by expanding our empirical analyses throughout 2011, it is possible to find out whether the basic relationships between trade, productivity, and wage inequality have changed in the U.S. in the last decade.

All of the objectives described above are accomplished within a trivariate time-series testing framework. Our empirical investigation, below, is divided into four sections. In section II, a thorough literature review concerning the effects of trade and other factors on wage inequality is undertaken. In section III, the data and the methodology used to investigate the relationship among these variables are outlined. The test results are described and analyzed in section IV. Section V concludes our paper with final remarks about the relationship between offshoring, wage inequality, and labor productivity in the U.S.

II. LITERATURE REVIEW

The literature on causes of wage inequality is a rich and varied one. Several explanations have been posited for the large and growing inequality in the United States [Katz and Autor, (1999)]. Most explanations fall under four broad categories: changes in relative demand for high-skilled versus low-skilled labor [Autor, Katz, and Kearney, (2008); Juhn, Murphy, and Pierce, (1993)]; changes in the relative supply of high-skilled versus low-skilled labor; institutional changes in the labor force; and compositional changes between high-skilled and low-skilled workers. Common demand based explanations are international trade and technological change (and related organizational changes). Common supply based explanations are changes in college graduation rates [Card and Lemieux, (2001); Goldin and Katz, (2009); Katz and Murphy, (1992)] and immigration [Altonji and Card, (1991); Borjas, (1995 and 2003); and Card, (2009)]. Institutional explanations [DiNardo, Fortin, and Lemieux (1996)] include minimum wage changes [Lee, (1999)] and changes in unionization [Kahn (2000)]. Finally, compositional explanations [Lemieux (2006)] claim that changes in inequality are unrelated to prices of high-skilled versus low-skilled labor, and are, rather, due to shifts in the relative quantities of high-skilled versus low-skilled labor.

The wage inequality literature has provided two main explanations for wage differentials. The first explanation is that demand, supply, and the decline in labor market institutions (unions and the minimum wage) were important components of the rise in inequality in the 1980's [Autor, Katz, and Kearney (2008)]. The second explanation is that continued increases in the relative demand for high-skilled labor, in the face of a stagnant relative supply of high-skilled labor, have played an important role in increasing wage differentials since the 1980's [Autor, Katz, and

Kearney (2008); Goldin and Katz (2009); and Katz and Autor (1999)]. However, even among those who accept a demand based argument for continued wage inequality, a vigorous debate about the ultimate cause of the rise in relative demand for high-skilled labor remains– with international trade and technology as the primary candidates. The technology argument posits that skill-biased technological change has occurred that favors high-skilled workers and thus raises their wage relative to low-skilled workers. The literature that emphasizes technology as an explanation for increased wage inequality has focused on three observations. First, that employment shifts towards high-skill intensive industries have been small relative to employment shifts towards high-skilled employment within industries [Bound and Johnson (1992); Berman, Bound, and Griliches (1994); and Berman, Bound, and Machin (1998)]. The argument is that this observation is largely inconsistent with the Heckscher-Ohlin (1933) framework, where the lowering of trade barriers should lead to an expansion of the high-skill-intensive sector. Second, there has been significant within industry substitution towards high-skilled labor despite an increase in the relative wage of high-skilled labor [Bound and Johnson (1992); Berman, Bound, and Griliches (1994); Berman, Bound, and Machin (1998); and Lawrence and Slaughter (1993)]. Third, that measures of computerization are associated with relative increases in high-skilled employment [Autor, Katz, and Krueger (1998); and Autor, Levy, and Murnane (2003)].

Conventional trade theory, which rests on the Heckscher-Ohlin (1933) model and the Stolper-Samuelson (1941) theorem, also provides a plausible explanation of wage inequality. According to conventional trade theory, increased trade with developing countries results in increased wage inequality in developed countries. However, this hypothesis has not been uniformly supported in the empirical literature. Empirical investigation of the impact of trade on wage inequality has left this issue largely unresolved. Most studies up to date have found only modest effects of trade on wage inequality [Edwards and Lawrence (2008); Feenstra and Hanson (1999); Krugman (1995); and Liu and Trefler (2008)].

It is clear from the above literature review of both theoretical explanations and empirical research on the causes of wage inequality that this issue is far from being resolved. We hope that our present research can provide additional information on this unresolved yet important issue. The focus of our paper is on analyzing the impact of offshoring on wage inequality and labor productivity in the U.S. To accomplish this objective, we deploy reduced form modeling of the time-series data.

III. DATA AND METHODOLOGY SELECTION

The data selection is determined by the hypotheses under empirical investigation. As stated above, the objective of our paper is to investigate the effects of offshoring on wage inequality and labor productivity in the U.S. One obvious way to measure the wage inequality is by computing the wage differentials between the L and the H types of labor wages. In this paper, the wages of L-tasks (those performed by low skilled labor) are approximated by the total private industry average weekly earnings of production and nonsupervisory employees (AWEP), while the wages of H-tasks (those performed by high-skilled labor) are measured by the average weekly earnings of production and nonsupervisory employees in the manufacturing sector of the U.S. (AWEM). The differences between these two wages (WD) are used as the measure of income inequality.

The selection of a variable that can be used to approximate offshoring is a challenging task, because there is no uniquely developed and accepted measure of offshoring. One way to obtain a quantitative measure of offshoring is to focus on the relationship between exports and imports through their impact on the terms of trade (TOT). When the terms of trade for the U.S. improves, it implies that the goods and services that the U.S. specializes in selling abroad (U.S. exports) by using its abundant factor (skilled labor) are experiencing a price advantage over the goods and services that countries with abundant unskilled labor are exporting to the U.S. (U.S. imports). Consequently, TOT reflects the relative prices of goods and services that are H-type goods and services versus L-type goods and services. Therefore, TOT is a measure of the incentive to offshore, and hence, it can be used to approximate the impact of offshoring on wage inequality in the U.S.[3] Using this approach to measure the impact of offshoring on income inequality makes it possible to test empirically the Grossman and Rossi-Hansberg (2006 and 2008) hypothesis. In this paper, the TOT variable is computed as the ratio of the BEA end of use export to import indexes. The selection of the labor productivity variable (PRODL) is straight-forward. It is approximated by the output per hour in the nonfarm business sector of the U.S.[4]

A further novelty of our research lies in its selection of the empirical methodology and testing specifications. The impact of offshoring on the wage inequality and labor productivity is investigated within a time-series testing framework. Quarterly data ranging from the first quarter of 1990 to the third quarter of 2011 are used in all subsequent data analyses.[5] The time-series testing framework requires that several steps be undertaken in econometric data analyses. Initially it is necessary to determine the stationarity or nonstationarity of each individual time-series variable. This determination is based upon the results of unit root tests. These tests determine the order of integration of each time-series variable under empirical investigation. If all time-series data are found to be integrated of order one I(1), then it is possible to find out if a long-run relationship exists among all of the test variables. This objective is accomplished within a cointegration testing framework. Cointegration test results determine the next step in the time-series data analyses. In particular, cointegration test determine whether vector error correction (VEC) or vector autoregression (VAR) testing framework is appropriate for further data analyses.

IV. INTEGRATION, COINTEGRATION, AND VEC TEST RESULTS

All the above outlined steps were followed in the present research. Initially all the data were subjected to unit root testing. As stated above, the objective of unit root tests is to determine the degree of integration of each individual time-series data.[6] Numerous unit root tests can be used to make this determination. The Phillips-Perron (1988) (PP) and the Augmented Dickey-Fuller (1976 and 1979) (ADF) tests are the most commonly used procedures to test the stationarity of time-series data. In the present paper, the Phillips-Perron test was used to make this determination. The results of this test are reported in Table 1. Unit root test results may be sensitive to a particular test specification, or an arbitrary lag selection. These tests can be conducted with or without the inclusion of the trend variable. In order to test the robustness of the PP test, both test specifications were examined. The PP tests indicate that all test variables, AWEP, AWEM, WD, PRODL, EXPORTS, IMPORTS, and TOT are nonstationary, and I(1).

Table 1
Phillips-Perron (PP) Test Results for AWEP, AWEM, WD, PRODL, EXPORTS, IMPORTS, and TOT

Variable	*Test Results Linear Trend Not Included*	*Test Results Linear Trend Included*
AWEP[1]	2.225	-2.097
AWEP[2]	-4.982**	-5.424**
AWEM[1]	0.569	-3.069
AWEM[2]	-7.188**	-7.182**
WD[1]	-2.149	-2.769
WD[2]	-7.117**	-7.095**
PRODL[1]	0.721	-2.027
PRODL[2]	-8.254**	-8.322**
EXPORTS[1]	1.725	-0.017
EXPORTS[2]	-5.014**	-5.104**
IMPORTS[1]	0.514	-1.299
IMPORTS[2]	-6.139**	-6.441**
TOT[1]	-1.879	-2.955
TOT[2]	–8.575**	–8.693**

[1]PP test results for the levels of variables
[2]PP test results for the first differences of levels of variables
**Indicates statistical significance at the one-percent level.

Given the fact that all individual time-series are I(1), it is possible that these variables are related in the long-run. This information would provide crucial information about the long-run relationship among offshoring, income inequality, and labor productivity in the U.S. This determination can be made by deploying cointegration tests. Although there exist numerous cointegration tests, all of these tests have one common objective - to find the most stationary linear combination of the vector time-series. The most commonly used cointegration tests are the Engle-

Granger (1987) test, the Stock and Watson (1988) test, and Johansen's (1988) procedure. Johansen's test appears to have several statistical advantages over the other above mentioned cointegration tests as noted by Gonzalo (1994). The superior statistical properties of Johansen's test include its ability to include all prior knowledge about the existence of unit roots in the time-series data under investigation, as well as the maximum likelihood estimation method that results in coefficient estimates that are symmetrically distributed and asymptotically efficient. Additionally, Johansen's method performs better in cases of nonnormal error distribution and where the dynamics of the model under investigation are not known. Given the superior statistical properties of Johansen's cointegration test, it was used to analyze the long-run relationships between PRODL, WD, and TOT. Test results are summarized in Table 2 below.

Table 2
Johansen Maximum Likelihood Cointegration Test Results for PRODL, WD, and TOT

Test Statistics	*Test Results Lags 1-2*	*Test Results Lags 1-4*
Trace Statistic	30.658*	32.226*
Max-Eigen Statistic	22.664*	23.411*

*Indicates statistical significance at the five-percent level.

Johansen's (1988) cointegration test results outlined in the above Table 2 imply that PRODL, WD, and TOT are cointegrated. This conclusion is reached by analyzing both the trace and the eigenvalue statistics. In both of these cases, the two test statistics (30.658, 22.664 and 32.226,23.411) are statistically significant at the conventional five-percent level. Additionally, the likelihood test indicates the existence of one cointegrating equation at the five-percent statistical significance level in both cases. The normalized cointegrating coefficient for PRODL, WD, and TOT is {1.00, -0.711, 237.379} in the 1-2 lag case, and {1.00, -0.810, 217.036} in the 1-4 lag test case. These cointegration tests provide important information about the relationship between offshoring, wage inequality, and labor productivity in the U.S. Clearly, these variables are related in the long-run. Consequently, it is fair to conclude that outsourcing tasks in goods and services may impact wage inequality and the labor productivity in the U.S. in the long-run. However, cointegration tests alone cannot determine the direction of causal flow among the three test variables. This information may be obtained by analyzing the short-run dynamics of the relationship between PRODL, WD, and TOT. This analysis can be undertaken within a VEC estimation framework.

One additional hurdle needs to be overcome in time-series data analyses. This problem involves lag determination in data testing. Lag selection has to be made in most time-series data testing procedures. In some test cases, such as the ADF (1976 and 1979) unit root test, this selection can be made automatically using numerous criteria, such as the SIC and the AIC criterion. In other time-series testing procedures, such as Johansen's (1988) cointegration test, lags can only be selected arbitrarily. An arbitrary lag selection can influence test results. This fact is well documented in economic literature [Thornton and Batten (1985), Hsiao (1979 and 1981), Saunders (1988), and others]. One way to mitigate this problem is by investigating more than one lag test structure, and determining whether test results are affected by doing so. Consequently, Johansen's (1988) cointegration test was repeated using the second lag structure (1-4 lags). The 1-4 lag specification test results are reported in Table 3. Clearly, these results were unaffected by this particular lag specification, as all variables were still found to be cointegrated. This fact attests to the robustness of the present model under investigation.

Cointegration test results determine the next step in the empirical investigation of the relationship between offshoring, wage inequality, and labor productivity in the U.S. Since the three variables are cointegrated, the VEC testing framework is the appropriate procedure to be deployed in the further analyses of this relationship. The main objective of the VEC modeling is to shed some light on the short-run dynamics among any number of time-series variables that are cointegrated. VEC modeling determines whether the system under empirical investigation is in a state of short-run equilibrium or disequilibrium. Additionally, in the present case, VEC estimates can provide some information on the short-run impact of offshoring on wage inequality and labor productivity in the U.S.

We adopt the Engle-Granger (1987) approach in VEC modeling of our time-series data. There are two important reasons for adopting this particular VEC testing procedure. First, the Engle-Granger VEC technique is ideally suited for use with Johansen's (1988) cointegration test. If the null hypothesis of cointegration of a group of variables is rejected by Johansen's test, that is if it is determined that such variables are cointegrated (as in the present case), then the residuals from Johansen's cointegration test can be used to estimate the Engle-Granger VEC model. In the present study, the saved residuals from the cointegrating equations reported in Table 2 above were used in subsequent VEC data modeling.[7] Second, using this particular form of VEC estimation allows us to make meaningful comparisons with our previously reported conclusions on the relationships between trade, income inequality, and labor productivity in the U.S. Given these two considerations, we adopt the Engle-Granger VEC approach in our present trivariate analyses of the TOT, WD, and PRODL data. Therefore, all of our test equations are specified as follows:

$$\Delta WD_t = \alpha_1 + \rho_1 z_{t-1} \sum_{j=1}^{2} \beta_{1j} \Delta WD_{t-j} + \sum_{j=1}^{2} \lambda_{1j} \Delta PRODL_{t-j} + \sum_{j=1}^{2} \delta_{1j} \Delta TOT_{t-j} + \varepsilon_{1tt} \tag{1}$$

$$\Delta PROD_t = \alpha_2 + \rho_2 z_{t-1} + \sum_{j=1}^{2} \beta_{2j} \Delta WD_{t-j} + \sum_{j=1}^{2} \lambda_{2j} \Delta PRODL_{t-j} + \sum_{j=1}^{2} \delta_{2j} \Delta TOT_{t-j} + \varepsilon_{2j} \tag{2}$$

$$\Delta TOT_t = \alpha_3 + \rho_3 z_{t-1} + \sum_{j=1}^{2} \beta_{3j} \Delta WD_{t-j} + \sum_{j=1}^{2} \lambda_{3j} \Delta PRODL_{t-j} + \sum_{j=1}^{2} \delta_{3j} \Delta TOT_{t-j} + \varepsilon_{3t} \tag{3}$$

The results of estimations of equations (1) – (3) are reported in Tables 3 and 4 below.

Table 3
VEC Estimates of Equations (1), (2), and (3). Lags 1-2

Equation	*Dependant Variable*	*Independent Variables*	*Coefficients*	*"t" Statistics*
1	DWD	Constant	-0.3399	-0.6240
		z(-1)	0.1181	2.1092*
		DWD(-1)	0.1411	1.2756
		DWD(-2)	0.0064	0.0634
		DPRODL(-1)	1.5780	2.5508*
		DPRODL(-2)	-0.0714	-0.1118
		DTOT(-1)	-24.8990	-1.2506
		DTOT(-2)	25.0175	1.2519
2	DPRODL	Constant	0.5992	5.7029*
		z(-1)	0.0466	4.3103*
		DWD(-1)	0.0140	0.6551
		DWD(-2)	0.0082	0.4185
		DPRODL(-1)	-0.1972	-1.6527
		DPRODL(-2)	-0.0641	-0.5207
		DTOT(-1)	-2.1944	-0.5714
		DTOT(-2)	-2.2629	-0.5870
3	DTOT	Constant	0.0002	0.0740
		z(-1)	-0.0003	-1.0182
		DWD(-1)	-0.0011	-1.6297
		DWD(-2)	-0.0009	-1.5531
		DPRODL(-1)	-0.0008	-0.2137
		DPRODL(-2)	0.0007	0.1842
		DTOT(-1)	0.2286	1.9577*

Table 4
VEC Estimates of Equations (1), (2), and (3). Lags 1-4

Equation	*Dependent Variable*	*Independent Variables*	*Coefficients*	*"t" Statistics*
1	DWD	Constant	0.6194	0.7926
		z(-1)	0.1805	2.5179*
		DWD(-1)	0.1934	1.6184
		DWD(-2)	0.0981	0.8350

table 4 contd.

Equation	*Dependent Variable*	*Independent Variables*	*Coefficients*	*"t" Statistics*
		DWD(-3)	0.2754	2.3558*
		DWD(-4)	-0.1211	-1.1342
		DPRODL(-1)	1.1735	1.7791
		DPRODL(-2)	-0.3566	-0.5481
		DPRODL(-3)	-0.9189	-1.4129
		DPRODL(-4)	-0.6019	-0.9319
		DTOT(-1)	-23.7387	-0.9559
		DTOT(-2)	9.6752	0.4100
		DTOT(-3)	16.4675	0.7621
		DTOT(-4)	-17.9732	-0.8461
2	DPRODL	Constant	0.8031	5.3657*
		z(-1)	0.0551	4.0114*
		DWD(-1)	0.0167	0.7315
		DWD(-2)	0.0312	1.3851
		DWD(-3)	-0.0155	-0.6993
		DWD(-4)	-0.0087	-0.4242
		DPRODL(-1)	-0.2771	-2.1932*
		DPRODL(-2)	-0.0924	-0.7412
		DPRODL(-3)	-0.1732	-1.3902
		DPRODL(-4)	-0.0931	-0.7528
		DTOT(-1)	-5.7711	-1.2134
		DTOT(-2)	-3.8036	-0.8416
		DTOT(-3)	-0.7817	-0.1889
		DTOT(-4)	0.2354	0.0579
3	DTOT	Constant	0.0024	0.5222
		z(-1)	-0.0002	-0.4744
		DWD(-1)	-0.0010	-1.4775
		DWD(-2)	-0.0007	-1.0453
		DWD(-3)	0.0007	0.9680
		DWD(-4)	-0.0003	-0.4037
		DPRODL(-1)	-0.0013	-0.3310
		DPRODL(-2)	0.0008	0.2047
		DPRODL(-3)	0.0000226	-0.0059
		DPRODL(-4)	-0.0056	-1.1929
		DTOT(-1)	0.2738	1.8553
		DTOT(-2)	-0.3677	-2.6221*
		DTOT(-3)	0.0677	0.5273
		DTOT(-4)	-0.0381	-0.3018

*Indicates statistical significance at the five-percent level.

The estimation results of equations (1) – (3) are outlined in above Tables 3 and 4. Although the same VEC estimation procedures are followed in both cases, the lag length is varied from 1-2 to 1-4 lags. The main reason for adding an additional lag specification is to test the robustness of our model. As mentioned previously, arbitrary lag selection can influence time-series tests results. Alleviating this potential problem, as we have done in the present case, adds to the strength of our statistical analyses as it is evident that varying the lag structure does not affect the key test results. An analysis of the estimates reported in the above two tables provides crucial information about how offshoring impacts wage inequality and labor productivity in the U.S. The focus of this analysis must be on the lagged z_t terms in all equations under investigation. The lagged z_t terms are the speed of adjustment residuals from Johansen's cointegrating tests carried out previously. Engle and Granger (1987) outline the methodology in this type of VEC data modeling. We follow their approach in our VEC data modeling. Essentially, VEC estimation determines whether the system under empirical investigation is in a state of short-run equilibrium or disequilibrium. This determination is based upon the statistical analysis of the lagged z_t terms. Conventional "t" tests are used to make this determination. Lagging these terms implies that disturbances of the last period may impact the current period. In general, finding a statistically insignificant coefficient of the z_t term implies that the state of the short-run equilibrium exists and there are no disturbances present. If this coefficient is statistically significant, then a state of short-run disequilibrium exists. In such a case, the coefficient estimate gives an indication of the size and the direction of the impact of explanatory variables on the dependent variable in the short-run. In the present case, this type of statistical analysis can provide crucial information about the effects of offshoring on wage inequality and labor productivity in the U.S.

The focus of the analysis is on the estimation of equations (1) and (2). These estimates provide crucial information about the effects of offshoring on wage inequality and labor productivity in the U.S. The coefficient of the lagged z_t term in equation (1) is statistically significant and positive. One obvious interpretation of this result is to conclude that offshoring and productivity growth have had a statistically significant impact on wage inequality in the U.S. Since the WD variable measures the gap between skilled and unskilled workers' wages, it would seem that offshoring has widened this gap. Equation (2) provides additional empirical evidence on the combined impact of offshoring and wage differentials on labor productivity. Since the coefficient of the lagged z_t term is both statistically significant and positive, this result implies that this impact is positive.

Equations (1) and (2) allow an empirical investigation of the previously outlined trade theorists' and labor economists' hypotheses about the causes of wage inequality to be undertaken in one combined model. Trade theorists maintain that trade can increase wage inequality. Trade affects wages of workers in exporting and importing sectors of an economy because it affects the prices of exports and imports. However, according to labor economists, wage differentials are primarily due to technological and productivity advances. Our VEC estimation results seem to support both of these hypotheses. They indicate that wage inequality has worsened due to the combined effect of offshoring and labor productivity changes. However, our present study's results do not support the Grossman Rossi-Hansberg (2006 and 2008) hypothesis about the impact of offshoring on wage inequality. It appears that although offshoring positively impacts labor productivity growth, it also widens wage inequality in the U.S. Our results imply that the positive productivity effect on wage inequality does not dominate the negative labor supply effect.

It is also worth noting that offshoring has changed the implications about the impact of trade on wage inequality that we reached in our previous research of this topic [Ghosh K., and Saunders P.J. (2002)]. In our 2002 study, we used the same empirical methodology to investigate the relationship between wage inequality, trade, and labor productivity. Our finding of a positive combined impact of trade and wage differentials on labor productivity was consistent with the results found in the present research. However, in our 2002 paper, we found no statistically significant combined impact of labor productivity changes and trade (approximated by net exports) on wage differentials (measured by the difference between the median incomes of bachelor's degree holders and those with only high school degrees). There are two likely explanations for the different conclusions reached in our present study. First, since our focus is specifically on investigating the impact of offshoring on wage inequality, the TOT variable used to approximate this effect is different from the net exports variable used in our previous study. Second, it is entirely possible that nine additional years of U.S. trade deficits and ever growing globalization may have changed the basic relationship between trade and wage inequality in the U.S. In any case, it appears that offshoring has lead to increasing income inequality in the U.S.

V. CONCLUDING REMARKS

Our paper investigates the impact of offshoring on wage inequality and productivity changes in the U.S. There are two key motivations for our empirical investigation of this topic. First, we provide an empirical framework for testing a new theory about the impact of offshoring on wage inequality outlined by Grossman and Rossi-Hansberg (2006 and 2008). According to their hypothesis, offshoring may not affect negatively the wages of low-skilled workers, because its positive productivity effect may dominate the negative labor supply effect and price effect. Therefore, according to the two authors, offshoring may not worsen wage inequality in the U.S. Second, our present research is a natural extension and a refinement of our previously published research on the relationship between wage inequality, trade, and labor productivity.

Our present study uses quarterly data ranging from the first quarter of 1990 to the third quarter of 2011 to analyze the impact of offshoring on income inequality and productivity changes in the U.S. Income inequality is measured by computing the wage differences between the L and the H types of workers. Low skilled labor

(L-tasks) wages are approximated by the total private industry average weekly earnings of production and nonsupervisory employees (AWEP). High skilled labor (H-tasks) wages are measured by the average weekly earnings of production and nonsupervisory employees in the manufacturing sector of the U.S. (AWEM). The differences between these two wages (WD) are used as the measure of income inequality in the U.S. One of the key contributions of our research to the ongoing debate about the effects of offshoring on income inequality is our development of the measure of offshoring that can be used to test empirically various outsourcing hypotheses. We approximate offshoring by the TOT variable that is computed as the ratio of the BEA end of use export to import indexes. The TOT variable determines how the gains from trade are distributed among trading countries. Since TOT reflects the relative prices of H-type goods and services versus L-type goods and services, this variable is well suited to measure the distribution of gains from trade between skilled and unskilled labor in the U.S. Therefore, the TOT variable is an ideal measure of the impact of offshoring on income inequality in the U.S. Furthermore, using this measure of income inequality allows us to test empirically the Grossman and Rossi-Hansberg (2006 and 2008) hypothesis about the impact of offshoring on low skilled labor wages in the U.S. The labor productivity variable (PRODL) is approximated by output per hour in the U.S. nonfarm business sector.

The time-series methodology used in our paper consists of unit root, cointegration, and vector error correction (VEC) estimation. The Phillips-Peron (1988) unit root tests indicate that all test variables are nonstationary, and integrated of order one I(1). Given this outcome, we deploy Johansen's (1988) cointegration test to analyze the long term relationships among WD, TOT, and PRODL. The cointegration test indicates the existence of a stable long-run relationship among these three variables. These results suggest that offshoring may have a long term impact on both wage inequality and labor productivity in the U.S. However, cointegration tests alone cannot make this determination. VEC estimation can accomplish this objective.

The key contribution of our paper to the ongoing debate of outsourcing on income inequality and labor productivity lies with its VEC data analyses. We use the Granger and Engle (1988) VEC test to analyze the short-run dynamics of the relationship among WD, TOT, and PRODL. Our test results indicate that outsourcing has had a positive impact on labor productivity in the short-run. Consequently, our results support the arguments about the effects of outsourcing on labor productivity made by both labor and trade economists. They are also consistent with the conclusions reached in our 2002 research. When analyzing the impact of offshoring on income inequality, we find that outsourcing worsens income inequality in the U.S. Therefore, the results of our present study do not support the new hypothesis about the effect of offshoring on income distribution proposed by Grossman and Rossi-Hansberg (2006 and 2008). It appears that outsourcing harms low-skilled workers in the U.S.

Notes

1. When analyzing the impact of international trade on services, it appears that the U.S. imports of Business, Professional, and Technical services have displayed double-digit growth rates for more than a decade. Such trade in service tasks, however, lags trade in manufacturing tasks. For example, in 2005, imports of private services into the U.S. only accounted for about 13 percent of total U.S. imports.
2. One of the novelties of the present paper lies in its empirical measure of offshoring. The data selection of this variable is described in detail in section III of this paper.
3. The labor content of U.S. exports is mostly skilled labor, whereas the labor content of U.S. imports is mostly unskilled labor. Consequently it would be fair to conclude that the unskilled workers in the U.S. work primarily in the import-competing sector, while the export sector of our economy primarily employs skilled labor. Since the U.S. exports goods and tasks that have a high content of skilled labor to the rest of the world, and imports goods and tasks that are largely produced by unskilled labor, the TOT variable (defined essentially as the ratio of exports to imports) can be used as a proxy for the cost of offshoring.
4. All data were obtained from the Bureau of Labor Statistics. Seasonally adjusted data were used for the AWEP and AWEM variables.
5. The selection of the data frequency was determined by the fact that offshoring only became an issue in the early to mid 1990s. Consequently, earlier time-series data were not included in this paper's estimates.
6. Statistical inferences about the degree of integration of individual time-series are based upon the presence or absence of unit roots in each data series. Unit root tests and their implications to time-series data analyses are well documented in the econometric literature. Detailed explanations of these issues are provided by Holden and Thompson (1992) and McCallum (1993), among others.
7. The Engle-Granger (1987) technique requires that several steps be followed in VEC data modeling. These steps include unit root and cointegration testing of time-series data. Detailed explanations of these steps are provided by Enders (1995), pages 373-81. All of these steps were followed in the present research.

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