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Abstract

It is well recognized that there emerged a trend of inward looking trade policies even before COVID pandemic crippled the world. These were reflected in both BREXIT and US-China trade conflict. As countries become inward oriented, usually local prices start rising. With this backdrop this paper explores how rising local prices are likely to affect employment in the short and long run when we accommodate for finite change in a general equilibrium structure whereby sectors not only contract but might close down altogether due to capital reallocation effect following a price incentive. Mechanisms behind employment increase are very much different between the short and the long run. We discuss such mechanisms and results in a variety of structures essentially highlighting the significance of the extensive margin, targeted protection and non-traded good.

JEL-Codes: F100, F110, F600.

Keywords: price increase, finite change, employment, general equilibrium, product variety.

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1. Introduction

It is well known in economics that in the presence of a nominal wage, an increase in product price will increase employment as marginal product of labour will fall with a lower real wage. What is seldom explored is such an effect in multi-sector context when many goods are produced with capital and labour. Recent trend in policy environment of the developed countries before COVID-19 pandemic emerged with devastating consequence has turned inward looking with BREXIT, US-China trade conflict, somewhat undermining trade negotiations at multilateral levels. This has set the stage for understanding the impact on unemployment when local prices start rising due to policy interventions. Conventional wisdom in a model with a fixed nominal wage is well known. But when each sector tries to expand, some may actually vanish and the employment effect becomes conditional on how capital is reallocated.

The purpose of this paper is to study such capital reallocation effect in three alternative $n-$sector general equilibrium production models, Specific Factor, Heckscher-Ohlin and a Hybrid.[1] In general capital tends to flow to the most labour intensive sector increasing employment but leading to vanishing sectors. Further we prove that if countries target import competing sectors for price support rather than uniform across the board price increase, employment either remains the same or declines relative to the uniform case. This is again due to capital reallocation impact. Our paper is an attempt to highlight the significance of extensive margin in determining policy outcomes.

We also discuss the case when there is a non-traded segment which might curtain the employment impact of price change because by definition these sectors do not shut down and prices adjust to accommodate changes in return to capital. Inward looking policies may fail to generate higher employment if this segment can expand in spite of a decline in labour income.

The literature on finite changes is quite extensive. One can refer to the works of Jones and Findlay (2000), Marjit and Mandal(2015), Beladi, Chakrabarti and Marjit (2016), etc in this

[1] The structure of the model in the present paper has its building blocks in the paper by Jones and Marjit (1992)

context.[2] The present paper attempts to consider the implications of finite changes in a general equilibrium framework and its consequence on aggregate employment. It actually considers the issue of price changes on the level of employment in the economy and attempts to examine whether the results under general equilibrium are same or different from the conventional belief in this regard. The present paper is in tune with the works related to the linkages between international trade and unemployment rates. The paper is related to other theoretical and empirical works on international trade and unemployment.

The important theoretical works include the works by Davidson, Martin and Matusz (1999), Helpman and Itskhoki (2010), Helpman, Itskhoki, and Redding (2010) etc and the important empirical works include the works by Felbermayr, Prat, and Schmerer (2011), Autor, Dorn, and Hanson (2013) etc. The theoretical studies mainly show that the impact of international trade on unemployment rate is ambiguous, whereas the empirical studies show that on an average international trade reduces unemployment rate in the long run. In the present paper we have considered the impact of inward looking policies on employment in a trade theoretic general equilibrium framework. Our paper is also related to the recent work of Marjit, Ganguly and Acharyya (2020), though the focus of the present paper is widely different from the above-mentioned paper.[3]

Under general equilibrium we have considered multi-sector Specific Factor, Heckscher-Ohlin (H-O) and a hybrid of the two models. In specific-factor model we find that price increase in one sector or increase in all sectors leads to an increase in aggregate employment. For the H-O model we have shown that price increase in all sectors by equal proportion causes only the most labour-intensive sector to survive and all other sectors to vanish, when capital is reallocated among sectors, so that the economy moves to a situation of complete specialization. First we consider a

[2] . See also Jones (2014), Jones (2018a, 2018b), Jones and Marjit (2009) and Jones (2012)

[3] Marjit, Ganguly and Acharyya (2020) have shown how a general equilibrium structure can lead to the positive impact of higher minimum wage on employment vindicating the empirical finding of Card and Krueger (1993). Their result is thus opposite to the conventional wisdom that higher minimum wage reduces employment. The present paper on the other hand considers a fixed minimum wage and examines how far the impact of price increase on employment as we find in the conventional literature in a partial equilibrium set is valid in a general equilibrium set up. In course of this examination we have also considered the implications of some policy issues which are sometimes different from the conventional belief.

multi-sector sector-specific model to examine the impact of price increase on aggregate employment. The model is then extended for n industries where each industry has m varieties. Next we consider the case when a subset of industries is protected depending on the trade pattern of the country. We compare the employment effect relative to the case of across the board price support and derive some interesting results. Finally we have considered the impact on employment as a result of inward looking policies due to the existence of non traded goods.

The rest of the paper is organized in the following manner. The basic model and its results are analyzed in section 2. The extended model is analyzed in section 3. Impact of protection to import-competing industries in the context of the extended version has been discussed in section 4. The case of non traded goods has been explained briefly in section 5. Finally, the concluding remarks are summarized in section 6.

2. The Basic Models and the Results

Inward looking policies tend to separate local price movements from global movements. In the comparative statics part we will focus when all prices of goods are uniformly increased. Mechanisms of how such a change affect employment will be very different in the short run specific factor and long run Heckscher –Ohlin models. In this section we first consider a specific factor model with n sectors where each sector uses two factors to analyze the effects of price change on employment. After this we switch over to a H-O model with n sectors and two factors to analyze the same effects.[4] The common assumptions of the model are small open economy, use of two inputs labor and capital by each sector, constant returns to scale (CRS), fixed wage rate in each sector etc. The symbols which are used for different models are briefly summarized as follows.

P_j = Domestic price of the product of sector j $(\forall j = 1,2,...n)$. We have $P_j = P_j^* (1+t)$, where P_j^* is the international price.

[4] The 2x2 H-O model and 2x3 specific factor model refer to the seminal works of Jones (1965) and Jones (1971) respectively.

$\overline{w}$ =Fixed wage rate of labor

r_j =Rate of return on capital in the jth sector $(\forall j = 1,2,...n)$

a_{ij} = Amount of i th input required to produce one unit of output of sector j $(\forall j = 1,2,...n)$, and $i = L, K$

λ_{ij} = Share of i th input used in j th sector out of total factor endowment (total capital endowment and total employment of labor) in physical terms $(\forall j = 1,2,...n)$ and $i = L, K$

θ_{ij} = Share of i th input used in j th sector out of total product of j th sector in value terms $(\forall j = 1,2,...n)$ and $i = L, K$

X_j = Output of sector j $(\forall j = 1,2,...n)$

K_j = Capital used by sector j $(\forall j = 1,2,...n)$

L_e = Level of employment in the economy

K = Capital endowment

$\overline{L}$ = Labor endowment

σ_j = Elasticity of factor substitution in sector j $(\forall j = 1,2,...n)$

Case I: Sector-specific model with n sectors

We consider capital as the specific factor and labor as the mobile factor. We write the competitive equilibrium condition for the jth sector $(\forall j = 1,2,...n)$ as

$$P_j = \overline{w} a_{Lj} + r_j a_{Kj} \quad (1)$$

Sector-specificity of capital for the jth sector $(\forall j = 1,2,...n)$ is given by

$$a_{Kj} X_j = K_j \quad (2)$$

For the sector–specific model K_j is assumed to be given

The level of employment is given by

$$\overline{L} > L_e = \sum_{j=1}^{n} a_{Lj} X_j \quad (3)$$

In this model when P_j increases in any one sector employment increases in that sector leading to an increase in aggregate employment. In fact when P_j increases in all the sectors employment also increases in all the sectors leading to an increase in the level of aggregate employment. The

intuition behind the result is simple. An increase in P_j raises the rate of return on capital in sector j which causes a reduction in unit demand for capital but raises the output of the jth sector for given level of capital stock used in this sector as we find from equation (2). Increase in P_j also raises the unit demand for labor in the jth sector, which along with the increase in the level of jth sector's output, increases employment. Hence employment in jth sector along with aggregate employment increases due to price increase. Each sector gives us a standard partial equilibrium result. The specific factor model is known as the short run model in trade theory as capital cannot flow between sectors. Now we turn to the longer run version, the H-O model.

Case II: H-O model with n sectors

We now focus on a n-sector version of an H-O model to illustrate the issue of employment as a result of change in price under general equilibrium. Here both capital and labor are assumed to be mobile among the sectors.

The competitive equilibrium condition for the jth sector $(\forall j = 1,2,...n)$ is given by[5]

$$P_j = \overline{w}a_{Lj} + ra_{Kj} \tag{4}$$

Mobility of capital among the sectors is given by

$$\sum_{j=1}^{n} K_j = K \tag{5}$$

The level of employment in the economy is given by equation (3) as specified earlier.[6] First note that this small economy will be completely specialized as all capital will flow to where it gets the highest return as a result of price increase and it will be a case of single sector partial equilibrium model. An increase in price in the surviving sector will lead to more employment. Suppose

[5] In equation (4) we have $r_j = r$ due to perfect capital mobility.

[6] Here unlike specific factor model the K_j s are variable. An alternative way of writing equation (5) is

$$\sum_{j=1}^{n} a_{Kj} X_j = K$$

instead we assume that the government provides price support to each sector so that they survive without vanishing and we are in a n-sector model to start with.

Since wage is fixed, when price increases in all the sectors uniformly only r will increase in all sectors and it increases by the highest amount in the sector which uses capital least intensively. In this case all capital will be reallocated to the most labor intensive sector increasing aggregate employment.[7] As a result of capital reallocation resulting from a uniform price increase causes a finite change so that all the sectors, other than the most labor-intensive sector, will shut down. This results in complete specialization in the economy along with increase in aggregate employment.[8]

Proposition 1: *a) A uniform increase in prices in the multi sector specific factor model must increase aggregate employment by increasing employment in each sector. b) A uniform increase in prices in H-O model will lead to finite change i.e. closure of all but the most labor intensive sector and aggregate employment will increase.*
Proofs- See the discussion above and the Appendix.

Note that the mechanism is entirely different in the short run and long run model i.e. without or with capital mobility. While in the short run capital is stuck, each sector gets the benefit of a rise in return to capital and expands employment, in the long run capital moves to the most profitable venture, shutting down all other activities. But aggregate employment must increase as it moves to the most labor intensive sector which raises the return most. This is capital reallocation impact missing in the short run and what is causing the finite change.

[7] The increase in the rate of return on capital will be highest in case of uniform price increase for the most labor-intensive sector. The increase in the rate of return on capital in the j th sector is given by $\frac{\hat{P}_j}{\theta_{Kj}}$ where θ_{Kj} is the lowest for the most labor-intensive sector so that the increase in the rate of return on capital is highest in this sector.

[8] When there is price increase only in the most labor-intensive sector the government may provide price support to other sectors which might otherwise shut down. If the price support is such that ultimately we have uniform price increase in all the sectors the results will be same as that of the case just mentioned here.

While in the short run the positive employment effect benefits all sectors and seems to complement the inward looking policies, the long run impact tends to specialization even if initially price support was in place that will be ineffective to stop capital to flow out to one sector. Unless the government arranges for further subsidies or protection, the country will be forced to depend on international trade.

3. The Extended Model

We now extend our analysis to an interesting combination of the specific factor and H-O model with large varieties of goods and industries. We assume that there are n industries where each industry produces a variety of goods. Each industry needs a specific capital and produces m varieties of goods specific to that industry. Any variety within an industry uses the same type of capital and labor but across industries capital types are different. Wage rate is fixed. So for each type of industry we have an H-O structure whereas for different industries we have a sector-specific structure. Given free trade and small country assumption, we consider an increase in prices of each industry in the model. The outcome will be as follows.

Each industry will produce one variety, the most labor-intensive variety, i.e. the variety which gives highest return to that capital and all other varieties will vanish unless some government support is given may be in the form of tariff protection for some other variety. In effect the model will converge to the specific factor model. Total employment will increase by cutting back number of varieties in each industry.

Suppose we consider industry i using capital of type i imply capital is specific to the industry. We consider that j th variety is produced by j th sector within industry i. Thus the competitive equilibrium condition for j th variety within industry i is given by

$$P_{ji} = \overline{w} a_{Lji} + r_{ji} a_{Kji} \tag{6}$$

The competitive equilibrium condition for v th variety within industry i is given by

$$P_{vi} = \overline{w} a_{Lvi} + r_{vi} a_{Kvi} \tag{7}$$

In a H-O framework for each variety within i th industry we have ultimately $r_{ji} = r_{vi} = r_i$ due to perfect capital mobility. Suppose there is an increase in the price of j th variety (produced by the j th sector) for industry i and there is no change in the price of any other variety within industry i. In this case we have $\hat{P}_{ji} > 0$ and $\hat{P}_{vi} = 0$ so that $\hat{r}_{ji} > 0$ and $\hat{r}_{vi} = 0$. Thus sector v will vanish and all the capital will flow to sector j to produce variety j. Hence in general as only one variety will be produced in the country the economy will be completely specialized in the production of that particular variety.

We next focus on the case of uniform increase in prices for different varieties within each industry. Here also for each variety we find that though the rates of return on capital will increase for all the varieties within each industry the increase in the rate of return on capital will be the highest for the most labor-intensive variety within each industry. Hence all specific capital and labor will move to the most labor intensive producing variety within each industry. This causes finite change and vanishing of all other varieties within each industry leading ultimately to increase in employment. The result is stated in terms of the following proposition.

Proposition 2: *In case of multiple industries each having a specific type of capital with product varieties for each type of capital; an across the board increase in prices increase employment by causing only the most labor-intensive variety of that industry to survive and the economy will be completely specialized in the production of that variety.*

Proof- For any given industry when all prices increase uniformly it is exactly like the n-sector H-O model and hence the proof is exactly the same as in proposition 1. Most labor- intensive variety in each industry promises the maximum increase in the rate of return of capital. Thus only one variety will be produced in each industry.

(For algebraic proof see appendix)

4. Protection of Import Competing Industries

It is reasonable to assume that any country following an inward looking policy will be inclined to target the import-competing sectors for a price support via import tax or production subsidies. In

that case one may consider uniform rates of tariff or uniform increase in prices for the import-competing goods and zero otherwise in our extended framework as mentioned earlier. One may compare the employment effect of such targeted policy with across the board uniform price rise assuming the extent of price rise being the same in uniform and non-uniform case. For the specific factor model the employment effect now will be weaker as some sectors will not be able to expand. This is obvious, but the H-O case is more interesting.

In case of the H-O model we consider two cases when import competing sectors are relatively labor-intensive and capital-intensive. In a way the first case matches with a developed country and the second with a developing country. We denote these cases as A and B respectively.

Case A

In this case relatively labor-intensive sectors are getting protection; hence the most labor-intensive sector must be one of them. As the subset of sectors experience uniform and proportionate price increase, only the most labor-intensive sector among them will survive and hence the employment effect will be exactly the same as in the case with across the board price increase. Thus targeting only relatively labor intensive sectors does not add anything to the earlier result.

Case B

In this case employment must fall as capital will be reallocated to capital-intensive segment. However, among the protected capital-intensive sectors only the most labor-intensive will survive. But employment is bound to fall relative to the earlier case when all prices rise by the same proportion. Thus uniform subsidy is a better deal than tariffs.

Thus targeted protectionist policies will not disturb the employment level in a developed country, but it will adversely affect employment in a developing economy otherwise pursuing a uniform price support as a reflection of inward looking policies.

5. The Case of Non Traded Good

Inward looking policies increase the significance of the non-traded goods. In fact some goods can cease to be traded if too much restrictions are imposed. But with the non-traded good the employment effect might not be positive, though the possibility does exist. An intuitive explanation will be good enough.

Suppose we continue to assume that one traded sector, say, sector 1, is the most labour intensive of all including the non-traded good. As all traded goods prices increase by same proportion and r increases accordingly, all capital in the traded good sectors will tend to go to sector 1. In the non-traded sector it is r which determines the price not the other way round. It has to adjust to the new r as determined from sector 1 and some additional capital will be allocated to the non-traded sector if it expands. Since the non-traded sector is more capital intensive than sector 1, there is a chance that employment can fall if the inflow of capital in the non-traded sector is excessive compared to sector 1. Note that the assumption of single non-traded sector is superfluous as we can have an entire non traded segment with many non-traded sectors each more capital intensive than sector 1 and each expanding and offering same r as in sector 1.

In the case without the non-traded segment when all capital flows to sector 1 employment must increase as it has the highest labour intensity and those with lower cannot pay capital as high r as dictated by the market. But now the non-traded segment in spite of being capital intensive relative to sector 1 can survive. We can now propose the following.

Proposition 3: *If capitalists' share of consumption for the non-traded good is small, employment must increase even when non-traded segment expands and non-traded goods are more capital intensive than sector 1.*

Proof- Suppose the stipulated share for the capitalists is close to zero. Then expansion in the non-traded segment, which must imply that there is an increase demand for the non-traded good, in turn implying that aggregate labour income has to expand and given a fixed wage aggregate employment must have increased. QED

It is easy to see that when workers do not consume the non-traded good, demand for non-traded good might increase even without a rise in employment.

6. Concluding Remarks

Inward looking policies in any country will tend to raise local prices relative to world prices. How this general change impacts employment in a fixed nominal wage general equilibrium model? The answer is that it will increase aggregate employment but the mechanism behind such a rise will be very different between the short and the long run. While in the short run there will not be any closure of industries, in the long run may industries will shut down. We extend the result in a model with many industries and variety of goods. If the governments of developing countries wish to avoid shut down of industries through protective policies and forces capital to be reallocated to the capital-intensive segment of different varieties, aggregate employment must fall and capital will be reallocated to the most labor-intensive among all the capital-intensive sectors. But for a developed country, employment effect of partial protection is the same as full scale price support.

Existence of a non-traded segment alters the basic perspective as finite change cannot shut down these sectors and we have shown how a uniform price increase in the traded segment may not generate higher employment when the non-traded segment can thrive independent of a rise in employment. This happens when capitalists are stronger consumers of these goods. Thus trade restriction can lead to unemployment even in models with a fixed nominal wage.

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Appendix

Proof of Proposition 1

(a) For part a , the sector-specific part, we find from equation (1)

$$\hat{P}_j = \theta_{Kj}\hat{r}_j \tag{A.1}$$

From equation (2) we get

$$\hat{X}_j = -\hat{a}_{Kj} \tag{A.2}$$

Considering σ_j as the elasticity of substitution in the j th sector and using the envelope property we can write

$$\hat{a}_{Kj} = -\sigma_j\theta_{Lj}\hat{r}_j \tag{A.3}$$

Using equations (A.2) and (A.1) we can obtain from equation (A.3) the following expression

$$\hat{X}_j = \sigma_j\theta_{Lj}\frac{\hat{P}_j}{\theta_{Kj}} \tag{A.4}$$

Using the envelope property and the definition of elasticity of substitution for sector j we can write

$$\hat{a}_{Lj} = \sigma_j\theta_{Kj}\hat{r}_j \tag{A.5}$$

Using equation (A.1) we can rewrite equation (A.5) as

$$\hat{a}_{Lj} = \sigma_j\hat{P}_j \tag{A.6}$$

Equation (3) implies

$$\hat{L}_e = \sum_{j=1}^{n}\lambda_{Lj}\hat{X}_j + \sum_{j=1}^{n}\lambda_{Lj}\hat{a}_{Lj} \tag{A.7}$$

Using equations (A.4) and (A.6) we can rewrite equation (A.7) as

$$\hat{L}_e = \sum_{j=1}^{n}\lambda_{Lj}\sigma_j\theta_{Lj}\frac{\hat{P}_j}{\theta_{Kj}} + \sum_{j=1}^{n}\lambda_{Lj}\sigma_j\hat{P}_j \tag{A.8}$$

When $\hat{P}_1 = \hat{P}_2 = ...= \hat{P}_n = \hat{P} > 0$ we can write the above equation after some simplification as

$$\hat{L}_e = \hat{P}\sum_{j=1}^{n} \lambda_{Lj} \frac{\sigma_j}{\theta_{Kj}} \tag{A.9}$$

Thus in case of uniform price increase for all sectors in the sector-specific model, i.e. $\hat{P} > 0$, we find aggregate employment increases, i.e. $\hat{L}_e > 0$

QED

(b) We now consider the proof for the H-O part, part b. We consider sector 1 as the most labor-intensive sector. From equation (3) we get equation (A.7) as mentioned earlier

Using the fact $K_j = a_{Kj} X_j$ we can rewrite equation (A.7) as

$$\hat{L}_e = \sum_{j=1}^{n} \lambda_{Lj} (\hat{K}_j - \hat{a}_{Kj}) + \sum_{j=1}^{n} \lambda_{Lj} \hat{a}_{Lj} \tag{A.10}$$

Using equation (5) we get

$$\hat{K}_1 = -\sum_{j=2}^{n} \frac{\lambda_{Kj}}{\lambda_{K1}} \hat{K}_j \tag{A.11}$$

Substituting equation (A.11) in equation (A.10) and noting that $\hat{P}_j = \theta_{Kj} \hat{r}_j$ we get

$$\hat{L}_e = \frac{1}{\lambda_{K1}} \sum_{j=2}^{n} (\lambda_{K1}\lambda_{Lj} - \lambda_{L1}\lambda_{Kj}) \hat{K}_j + \sum_{j=1}^{n} \lambda_{Lj} \sigma_j \frac{\hat{P}_j}{\theta_{Kj}} \tag{A.12}$$

In equation (A.12) we assume $\frac{\lambda_{K1}}{\lambda_{L1}} = \min \frac{\lambda_{Kj}}{\lambda_{Lj}} \; \forall j = 1,2,.....n$. It implies sector 1 is the most labor-intensive sector which implies $\frac{\lambda_{K1}}{\lambda_{L1}} < \frac{\lambda_{Kj}}{\lambda_{Lj}} \forall j = 2,.....,n$ so that the first term within bracket in equation (A.12) is negative. We also have $\hat{K}_j < 0 \text{ and } \sigma_j > 0$. When $\hat{P}_1 = \hat{P}_2 = ...= \hat{P}_n = \hat{P} > 0$ we can rewrite equation (A.12) as

$$\hat{L}_e = \frac{1}{\lambda_{K1}} \sum_{j=2}^{n} (\lambda_{K1}\lambda_{Lj} - \lambda_{L1}\lambda_{Kj}) \hat{K}_j + \hat{P} \sum_{j=1}^{n} \lambda_{Lj} \frac{\sigma_j}{\theta_{Kj}} \tag{A.12.1}$$

It is to be noted that in equation (A.12.1) we have $\hat{P} > 0$ which implies $\hat{L}_e > 0$ so that when all prices rise by uniform amount aggregate employment increases.

From equation (A.1) we find that the rate of return on capital in the j th sector is given by $\frac{\hat{P}_j}{\theta_{Kj}}$ and as sector 1 is the most labor-intensive sector θ_{K1} is the lowest among all the sectors. So in case of uniform increase in price in all the sectors we find that the increase in rate of return on capital is highest in the most labor-intensive sector, i.e. sector 1. Hence all capital flows to sector 1 and apart from sector 1 all other sectors will vanish.

QED

Proof of Proposition 2

The proof of this proposition is similar to that of part b of proposition 1 as the present proposition is a generalization of that. There are n industries and each industry produces m varieties with specific capital for each industry. Thus there are n types of capital where each industry uses K_i capital ($\forall i = 1,2,....n$) and capital K_i is perfectly mobile among the m varieties. Hence we write

$$\sum_{j=1}^{m} K_{ji} = K_i \tag{A.13}$$

For the j th variety (or sector) within industry i we write the competitive equilibrium condition as

$$P_{ji} = \overline{w} a_{Lji} + r_i a_{Kji} \quad (\forall j = 1,2,.....m) \tag{A.14}$$

Using the fact $K_{ji} = a_{Kji} X_{ji}$ capital mobility of i th type of capital is given by

$$\sum_{j=1}^{m} a_{Kji} X_{ji} = K_i \tag{A.15}$$

The level of employment in i th industry is given by

$$L_i = \sum_{j=1}^{m} a_{Lji} X_{ji} \tag{A.16}$$

Total employment is given by

$$\overline{L} > L_e = \sum_{i=1}^{n} L_i \tag{A.17}$$

We can rewrite equation (A.16) as

$$\hat{L}_i = \sum_{j=1}^{m} \lambda_{Lji} \hat{X}_{ji} + \sum_{j=1}^{m} \lambda_{Lji} \hat{a}_{Lji} \quad \text{(A.18)}$$

Using the fact $K_{ji} = a_{Kji} X_{ji}$ and just like the case of proposition 1 we can rewrite equation (A.18) as

$$\hat{L}_i = \sum_{j=1}^{m} \lambda_{Lji} (\hat{K}_{ji} - \hat{a}_{Kji}) + \sum_{j=1}^{m} \lambda_{Lji} \hat{a}_{Lji} \quad \text{(A.19)}$$

For given K_i, from equation (A.13) we get

$$\hat{K}_{1i} = -\sum_{j=2}^{m} \frac{\lambda_{Kji}}{\lambda_{K1i}} \hat{K}_{ji} \quad \text{(A.20)}$$

Substituting equation (A.20) in equation (A.19) and noting that $\hat{P}_{ji} = \theta_{Kji} \hat{r}_i$ we get

$$\hat{L}_i = \frac{1}{\lambda_{K1i}} \sum_{j=2}^{m} (\lambda_{K1i} \lambda_{Lji} - \lambda_{L1i} \lambda_{Kji}) \hat{K}_{ji} + \sum_{j=1}^{n} \lambda_{Lji} \sigma_{ji} \frac{\hat{P}_{ji}}{\theta_{Kji}} \quad \text{(A.21)}$$

A uniform increase in price for all varieties for industry *i* implies $\hat{P}_{1i} = \hat{P}_{2i} = ... = \hat{P}_{mi} = \hat{P}_i > 0$. In equation (A.21) we assume $\frac{\lambda_{K1i}}{\lambda_{L1i}} = \min \frac{\lambda_{Kji}}{\lambda_{Lji}} \; \forall j = 1,2,.....m$. It implies variety 1 is most labor-intensive among all the varieties which implies $\frac{\lambda_{K1i}}{\lambda_{L1i}} < \frac{\lambda_{Kji}}{\lambda_{Lji}} \forall j = 2,.....,m$ so that the first term within bracket in equation (A.21) is negative. Here we find $\hat{K}_{ji} < 0$ and $\sigma_{ji} > 0$. Thus $\hat{P}_i > 0$ implies $\hat{L}_i > 0$. The part on shutting down of all varieties except the most labor-intensive variety within industry '*i*' is same as that of proposition 1(b).

QED